BRITISH FRESH-WATER COPEPODA

BY

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VOLUME III

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Little Girl: "What's that, daddy?"
Father: "A cow."
Little Girl: "Why?"
—*Punch.*

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PREFACE.

It was my expectation and hope that the task of dealing with the genus *Cyclops* would be a light one, since Kiefer's revision of the Cyclopoida Gnathostoma for the 'Tierreich,' together with his previous explanatory papers, provides a complete summary of present knowledge of the subject. The painstaking thoroughness of his work places all who are concerned with fresh-water Copepods in his debt; but I have found myself so much in disagreement with some of his results that, in some ways, the labour has been heavier than it would otherwise have been. Kiefer is the leader of the "new school" which regards revision of the old species concepts as urgently necessary, and the smallest observable differences as sufficient to characterize new species. There is no doubt that an overhaul of our conception of species is a salutary thing, and that the results in some cases have been illuminating. For example, the old species *C. strenuus* has been revealed as a series of specific groups, some of which have definite ecological characters. It is, however, very doubtful if it is wise to continue the analysis so far as is being done without an adequate backing of experiment, or at least of comparison of abundant material. One unfortunate result of the work of the new school is that all previous work has come into suspicion, if not disrepute. For example, in a paper by Kiefer on the *Cyclops* of India (1928), every species previously recorded, with two exceptions, is entered either with "?" or an expressed doubt. It comes to this, that unless we accept the ruling of the new school, or publish figures of every species we record, our record is vain. No doubt many

older records are open to some suspicion, but I am not prepared to agree to sweep them all away as lumber and begin again. When I entered on the preparation of this work it was with a prepossession in favour of the "meticulists," but I feel more and more driven to the view that it is not in this direction that progress will be made. It seems, broadly speaking, that there are relatively few "major species" of *Cyclops*, most of which are found in Europe, and that round each can be gathered satellites, which one can designate as species only at the peril of losing grasp of reality. The botanists have had a longer and sadder experience of the meticulist school than we have, and there has risen from their ranks a wail of despair, from which we may take warning.

It has been made clear that many Linnean species can be resolved into a multitude of "elementary species" or "jordanons," and it may well be that these minor units are the only objective realities; but it is certainly true that the majority of botanists or zoologists cannot work with such units. So long ago as 1908 the principal speaker at a congress of botanists in America deplored in the strongest possible language the desperate position of systematic botany. He instanced the genus *Cratægus*, which is now removed from the field of study of the ordinary botanist by the impossibility of recognizing the multitude of species within it. As Prof. Berry remarked, "A species has no legitimate reason for existence whose limits are perceptible only to its maker." Hall and Clements, whose work on *Artemisia* and other genera (1923) is a fine example of the application to systematics of experiment and observation in the field, have much to say of the effects of "segregation." They conclude, "Meanwhile the gap between the systematists and those they serve widens, and it can only be bridged by the type of botany that frankly regards the needs of the latter as paramount."

I must confess to some caprice in estimating the status of species in *Cyclops*. In the case of such closely allied forms as *C. viridis* and *C. gigas*, *C. strenuus* and

C. furcifer, *C. vernalis* and *C. americanus*, it is largely a matter of personal choice whether they are all to be called species or not. Where the difference is clear-cut and distinction is easy, and there are also ecological differences, it seems best to regard the two forms as species ; but, where either criterion is weak or fails, to regard one as a subspecies of the other. The definition of subspecies given in Vol. I (p. 29) cannot be applied in the case of *Cyclops*, and the term does not indicate a geographically limited race in the sense of a unit in a "Rassenkreis." What the relation of the members of such a subspecies is to the parent form or to each other is at present quite unknown.

Something must also be said here about the limitation of genera. Very large, undivided genera are, in practice, very inconvenient, but to break up such a genus into a number of smaller genera of equal rank is apt to obscure the relationship of the units. This objection is largely met by making the smaller units subgenera, just as the objection to splitting species is largely met by making the new units subspecies. It is necessary to beware of making too many subgenera, since, the finer the distinctions drawn, the more difficult it is to make these units practically useful. In the case of *Cyclops* the distinctions drawn by Kiefer are often so fine as to be, in my opinion, quite unpractical. It may often be the case that one can discern related groups of species within a genus or subgenus, and yet be unable to frame an unambiguous definition for them. In such cases a shadowy definition with a name seems to be positively harmful. The relation can be expressed much better by Schmeil's "groups." Any other course is bound to lead in the end to the subgenus approaching very near to the limit of the species. The process of narrower and narrower limitation of groups is also cumulative. It becomes more and more difficult to place a new species in an established group, and another new genus or subgenus has to be made to receive it. For this reason I feel it is most unfortunate that Kiefer should have

extended his work to the genus *Diaptomus* (1932D), within which he has made ten new genera and a number of subgenera, without taking into account the North-American species.

I am greatly indebted to Mr. Scourfield and to Mr. Lowndes for much help freely given. Both have been good enough to read the MS. of this volume, and have offered friendly criticism which has been much valued.

ROBERT GURNEY.

BOARS HILL;
December, 1932.

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THE BRITISH FRESH-WATER COPEPODA.

THE CLASSIFICATION OF THE CYCLOPOIDA AND THE PARASITIC FORMS DERIVED FROM THEM.

I HAVE already discussed (Vol. I, p. 22) the rival systems of classification of Giesbrecht and Sars, so far as concerns the major groups, concluding that, while Giesbrecht's system has much to recommend it as a means of expressing phylogeny, that of Sars is on the whole more convenient and adaptable. Since I have now to deal with the Cyclopoida and certain parasitic forms, it is necessary to return to the question as to how far present views on phylogeny can be expressed within the framework of the system adopted. Sars included in the Cyclopoida all the free-swimming and semi-parasitic Podoplea, but he set up new and equivalent groups for the Harpacticidæ, Monstrillidæ, Caligidæ, Lernæidæ and their allies, rejecting Giesbrecht's subdivision of the Podoplea into Isokerandria and Ampharthrandria. Brehm (1927) has attempted a new grouping which unites to some extent both systems, but, in my opinion, his system rather perpetuates their defects than their advantages. Within the Podoplea he includes all the free-swimming and semi-parasitic forms, and also the Notodelphyidæ, while he sets up 8 suborders, each equivalent in status to the "Podoplea," for the parasitic forms. The subdivision of the Podoplea into the tribes Pœcilostomata, Monstrillidea, Ampharthrandria, Misophriidea and Harpacticoidea shows how heterogeneous the whole group is. The Monstrillidea have no apparent relation

to any of the other groups, unless we accept, on the shadowy evidence of the thoracic segmentation of *Thaumatopsyllus*, a possible connection with the Cancerillidæ; while it is difficult to agree that there is so fundamental a separation as Brehm would show between the Pœcilostomata and the Cyclopidea. The relegation of the parasitic forms to so many suborders is a confession of ignorance of their phylogeny which goes beyond what is necessary.

No system of classification can claim to be adequate until some agreement is reached as to the probable lines of evolution of the parasitic forms, and we are at present very far from having that knowledge. There is good reason for recognizing a relation between the Chondracanthidæ and the Ergasilidæ, and there cannot be any question that the Lernæidæ, Dichelesthiidæ and Caligidæ are very closely related; but we are quite unable to suggest a derivation of the latter families from any existing free-swimming group. In the case of the Notodelphyidæ, where the appendages have retained a primitive form, there is such close resemblance to the Cyclopinidæ that Schellenberg has claimed direct descent. At the same time the Notodelphyidæ have diverged so far in the direction of parasitic degeneration that it is rather misleading to include them simply within the Cyclopinid series, as Brehm has done.

Oakley (1931)* has suggested the following grouping of the parasitic Copepods:

CYCLOPIFORMES.—One or both sexes cyclopoid, with non-suctorial mouth, simple or falciform mandibles, small genital somite, no frontal filament:

Ergasilidæ.
Juanettiidæ.
Chondracanthidæ.
Monstrillidæ.

* Monod and Dollfus (1932) adopt Oakley's division of Cyclopiformes to include also all the free-swimming forms, which Oakley himself did not definitely do.

Caligiformes.—One or both sexes, or larva, caligoid; suctorial mouth tube, styliform mandibles, large genital somite, frontal filament (except in Euryphorinæ):

Caligidæ.
Dichelesthiidæ.
Lernæidæ.
Lernæopodidæ.
Choniostomatidæ.
Herpyllobiidæ.

This system has the advantage of bringing the Chondracanthidæ and the Lernæidæ into a more natural setting; but separates the Ergasilidæ from their allies, the Corycæidæ, and associates them with the Monstrillidæ, with which they have no apparent relation.

With Oakley's union of all the remaining parasitic forms in a single group I have much sympathy. With an increased knowledge of the ontogeny the old divisions have largely broken down, and it becomes most difficult to find any fundamental distinction between the groups. It is at least possible that the whole of the parasitic forms are sprung from a single stem. That the Caligoida and Lernæidæ must be included in a single section is perfectly clear, and, having done so, it is hardly possible to separate from them the Nicothoidæ and Choniostomatidæ. The Herpyllobiidæ remain of rather obscure affinity. Whether one is also justified in including the Lernæopodidæ is, however, rather more doubtful. The difference in ontogeny, in the arrested development of the male, and in the means of attachment, are sufficient to suggest diversity of origin, and it may be better, for the present, to retain a separate division for them.

It is rather doubtful if we are still justified in separating so widely the Ergasilidæ from the Caligidæ. Some genera, such as *Assecula*, seem to bridge the gap, so far as the adults are concerned, and it is not unlikely that we may ultimately be forced to recognize in the Ergasilidæ the parents of all the parasitic forms. *Nicothoë*

is a genus of disputed position, possibly related to the Ergasilidæ, and almost certainly nearly related to the Choniostomatidæ. If this is so, here is further ground for looking to the Ergasilidæ as the parents of all the parasitic forms, though probably along more than one divergent line.

The following arrangement, founded upon that of Sars with some modification, seems to express our present knowledge reasonably well.

COPEPODA.

Order I. Calanoida.
" II. Misophrioida.
" III. Monstrilloida.
    Thaumatopsyllidæ.
    Monstrillidæ.
" IV. Harpacticoida.
" V. Cyclopoida.
  Suborder 1. Gnathostoma.
    Oithonidæ.
    Cyclopinidæ.
      Cyclopininæ.
      Pterinopsyllinæ.
    Cyclopidæ.
      Euryte.
      Halicyclops.
      Cyclops.
  Suborder 2. Siphonostoma.
    Ascomyzontidæ.
    Acontiophoridæ.
    Myzopontiidæ.
    Dyspontiidæ.
    Artotrogidæ.
    Cancerillidæ.
  Suborder 3. Pœcilostoma.
    Clausidiidæ.
    Lichomolgidæ.
    Oncæidæ.

Corycæidæ.
Ergasilidæ.
Chondracanthidæ.
Juanettiidæ.
Splanchnotrophidæ.
Clausiidæ.
Eunicicolidæ.*
Philichthyidæ ?

Order VI. Notodelphyoida.
,, VII. Caligoida.
Series 1. Caligiformes.
Caligidæ.
Dichelesthiidæ.
Series 2. Lernæiformes.
Sphyriidæ.
Lernæidæ.
Series 3. Achtheriformes.
Lernæopodidæ.
Series 4. Nicothoiformes.
Nicothoidæ.
Choniostomatidæ.
Herpyllobiidæ.

CYCLOPOIDA, Sars.

1886. *Cyclopoidea*, Sars, Norske Nordhavs-Exp. VI, p. 79.
1910. *Cyclopidea*, Stebbing, Ann. S. Af. Mus. VI, p. 547.
1913. *Cyclopoida*, Sars, Crust. Norway, VI, p. 1.
1927. *Ampharthrandria* (part), Brehm, Kükenthal, Handb. Zool. III, p. 490.
1929. *Cyclopoida*, Kiefer, Tierreich, Lief. LIII, p. 1.

Head and thorax generally ovoid, markedly broader than abdomen ; head usually fused with thorax. Abd. soms. 1 and 2 of female fused to form genital somite, commonly with median receptaculum seminis. Furcal rami with 4 apical setæ, of which the median pair are generally very long and jointed at base. Antennules of male symmetrical, generally both prehensile. Antennæ

* A further examination of *Eunicicola* seems to be required, to confirm Sars's statements regarding the relation of mouth and sucker, and absence of mandibles. There is strong resemblance to Choniostomatidæ.

uniramous, or with vestigial exopodite (some Siphonostoma). Mouth-parts much modified in parasitic and semi-parasitic forms, but resembling those of Calanoida in some free-swimming forms. Swimming-legs all very much alike, leg 1 never prehensile; very rarely with small sexual differences. Leg 5, uniramous, very small, alike, or nearly alike, in both sexes. Heart absent. Sexual openings paired; in female on each side of genital somite, or more or less dorsal. Male sexual apparatus paired, but testis single.

Egg-sacs paired, very rarely single (*Corycæus*).

Suborder **GNATHOSTOMA**, Sars.*

1913. Sars, Crust. Norway, VI, p. 3.

Both antennules of male geniculate. Antennæ without exopod, and without terminal claws. Mandibles and maxillules well developed, with dentate chewing edges. Maxillipedes not prehensile, without sexual differences.

The Gnathostoma of Sars form three natural and distinct series, represented by their typical genera, *Oithona*, *Cyclopina* and *Cyclops*. Concerning the first there is no doubt; but there is some difficulty about certain genera in the other two. Kiefer (1929) recognizes the three series as Oithonidæ, Cyclopinidæ and Cyclopidæ, but makes in each two subfamilies; in the former Cyclopininæ and Pterinopsyllinæ, and in the latter Halicyclopinæ and Cyclopinæ.

The position of *Euryte* and *Halicyclops* is not clear. They are placed in the Cyclopidæ mainly on the ground that the mandibular palp is lost, and they are grouped together by Kiefer solely on the structure of leg 5, which, in *Euryte*, has the Cyclopinid character. There does not seem to be any closer relationship between *Euryte* and *Halicyclops* than between the latter and *Cyclops*, as should be the case to justify their union in

* Thorell, who introduced the term "Gnathostoma" in 1859, used it to include Calanidæ, Cyclopidæ, Notodelphyidæ and Buproridæ.

a subfamily. It is possible that *Euryte* represents a diverging Cyclopinid stem leading to the Pœcilostoma such as *Hemicyclops* (Clausidiidæ), while *Halicyclops* is a quite different branch from a pre-*Cyclops* stem, which also gave rise to the Trifida group of *Cyclops*. The similarity of the nauplius of *Halicyclops* and *Cyclops fuscus* is very striking. They have the same transverse row of ventral hairs, the same form of exopod of the antenna, and the very long inner seta on the mandible which is not seen in any other group. Such a view cannot easily be expressed in any systematic arrangement, which is necessarily linear and discontinuous. It requires the separation of *Euryte* from *Halicyclops* ; but to leave the former with the Cyclopinidæ, which one would prefer to do, destroys the unity of that family, and makes more difficult a separation from the Cyclopidæ. The simplest practical course is to leave it in the Cyclopidæ, but to allow it to form a subgroup, independent alike of *Halicyclops* and of *Cyclops*.

CYCLOPINIDÆ, Sars.

1913. Sars, Crust. Norway, VI, p. 9.
1929. Kiefer, Tierreich, Lief. LIII, p. 12.

Segment of leg 1 united with head (except in *Cyclopinella*). Antennule with from 6 to 26 segments, prehensile in male, with middle part swollen. Antenna of 4 segments without exopod. Mandible with large biramous exopod. Maxillipede generally with segmented endopod. Legs with rami 3-segmented, the outer spines generally with hyaline borders. Leg 5, 2- or 3-segmented, the apical segment flattened, with 3 or 4 spines or setæ. Two lateral egg-sacs.

CYCLOPININÆ.

Cyclopina, Claus.
Cyclopinella, Sars.
Cyclopetta, Sars.

PTERINOPSYLLINÆ.

Pterinopsyllus, Brady.

CYCLOPININÆ, Kiefer.

1929. Kiefer, Tierreich Lief. LIII, p. 12.

Antenna 4-segmented. Antennule of male without remarkably large sense-cylinders. Endopods of legs 1 and 4 without sexual differences.

CYCLOPINA, Claus.

1863. Claus, Freileb. Cop. p. 103.
1900. Giesbrecht, Mitth. Stat. Neap. XIV, p. 40.
1913. Sars, Crust. Norway, VI, p. 10.
1929. Kiefer, Tierreich, Lief. LIII, p. 13.

Antennules of 10–26 segments. Antenna 4-segmented. Mandible with biramous palp, the exopod 4-segmented. Maxillule with vestigial exopod. Maxillipede with endopod of several segments. Legs 1–4 with rami of 3 segments. Leg 5 of 2 or 3 segments in female, seg. 2 with 3–5 setæ or spines.

Type : *C. gracilis*, Claus.

The species of *Cyclopina*, of which 16 have been sufficiently described, are mostly marine and littoral. Three species are known from brackish water in India and the Chatham Islands (*C. intermedia*, Sewell, *C. longifurca*, Sewell, *C. pusilla*, Sars). In this country the form treated here as *C. norvegica* is quite commonly found in estuaries, and is included here for that reason, but it can hardly be regarded as a strictly brackish-water species. *C. littoralis*, Brady, has occasionally been taken in the estuaries of the east coast, but it is not really an estuarine species.

The following species are known from the British coasts : *C. gracilis*, Claus ; *C. longifurcata*, Scott ; *C. elegans*, Scott ; *C. littoralis*, Brady ; *C. pygmæus*, Sars (Plymouth).

Cyclopina norvegica, Boeck.

(Figs. 1196–1216.)

1864. *C. norvegica*, Boeck, Forh. Vid. Selsk. Christ. p. 247.
1882. *C. gracilis*, Giesbrecht, Ber. Comm. D. Meere, IV, p. 137, figs.
? 1880. ,, Brady, Mon. Brit. Cop. I, p. 93, figs.
? 1900. *Cyclops salinus*, Brady, Trans. N. H. Soc. Northd. XIII, p. 432, figs.
? 1904. ,, ,, Brady, *ibid.*, N.S. I, p. 5, figs.
1921. *C. norvegica*, Sars, Crust. Norway, VII, p. 102, figs.
1929. ,, Kiefer, Tierreich, Lief. LIII, p. 16, fig.

Female.—Length ·58–·62 mm.

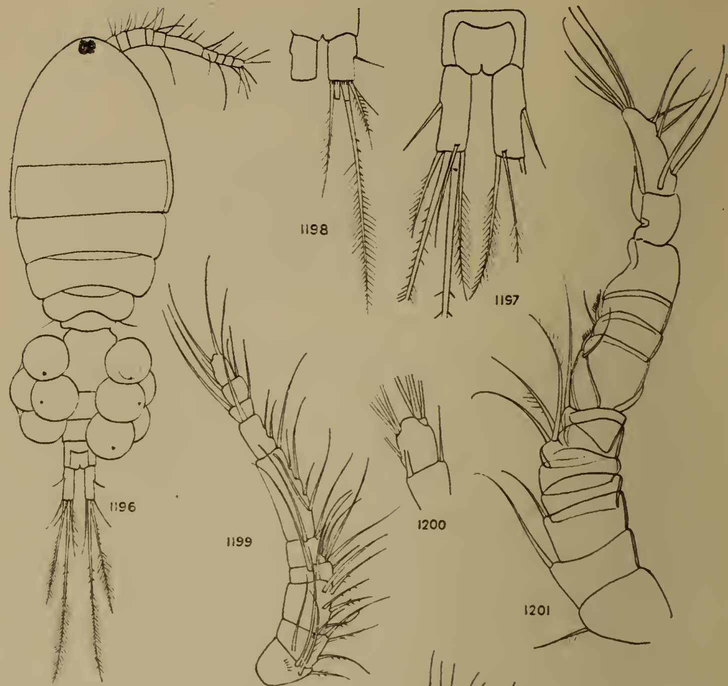
Head and thorax about twice as long as broad, the head region broadly rounded in front, not tapering. Genital somite slender, about as long as two following somites together. Furcal rami about 3 times as long as wide, the lateral seta inserted a little in front of middle; outer apical seta about two-thirds length of inner, and a little longer than ramus.

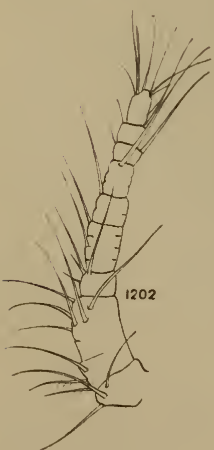
Antennules much shorter than cephalothorax, of 10 segments, of which the 6th is strikingly elongated, and bears a slender æsthete near base; seg. 10 short, with 6 apical setæ and æsthete. Antenna of 4 segments; seg. 3 very small, and seg. 4 shorter than seg. 2, about $2\frac{1}{2}$ times as long as broad. Mandible palp with one seta on basis and 3 on seg. 1 of endopod; exopod with segs. 1 and 2 partly fused. Legs with spine formula 4.4.4.3. Leg 1 endopod 3 much wider than long, with a spinous process on outer distal angle. Leg 4 endopod 3 less than twice as long as broad, with 2 apical setæ of equal length.

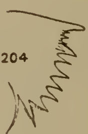
Leg 5 2-segmented, seg. 2 oval, about $1\frac{1}{2}$ times as long as broad (32 : 20). Inner apical spine much shorter than outer (30 : 46).

Male.—Length ·46 mm.

Furcal rami much shorter than in female, about twice as long as wide, and with lateral seta placed more in front. Furcal setæ somewhat longer than in female.

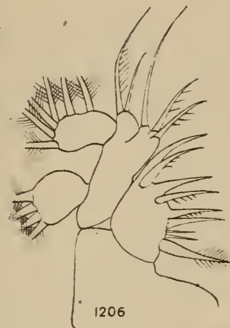


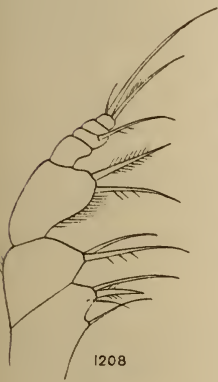


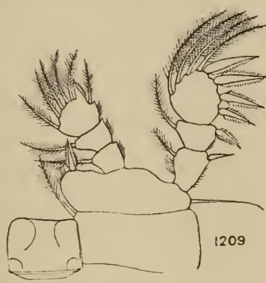


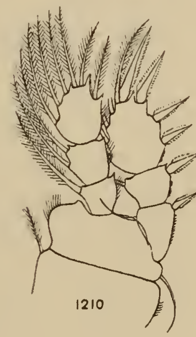
FIGS. 1196–1204.—*Cyclopina norvegica.*

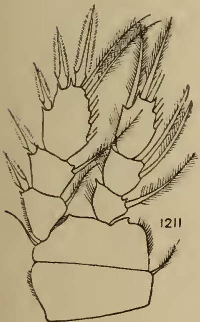
FIG. 1196.—Female, dorsal.
FIG. 1197.—Furcal rami, female, dorsal.
FIG. 1198.—Furcal rami, male, ventral.
FIG. 1199.—Antennule, female.
FIG. 1200.—Antennule, female, apical segment.
FIG. 1201.—Antennule, male.
FIG. 1202.—Antennule, male, last copepodid.
FIG. 1203.—Antenna.
FIG. 1204.—Mandible, cutting edge.

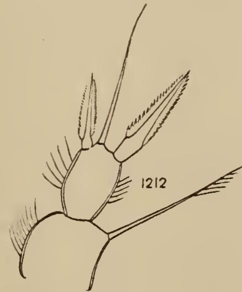


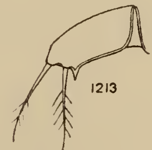












FIGS. 1205–1213.—*Cyclopina norvegica.*

FIG. 1205.—Mandible palp.
FIG. 1206.—Maxillule.
FIG. 1207.—Maxilla.
FIG. 1208.—Maxillipede.
FIG. 1209.—Leg 1.
FIG. 1210.—Leg 2.
FIG. 1211.—Leg 4.
FIG. 1212.—Leg 5, female.
FIG. 1213.—Leg 6, male.

Antennule: I have not been able, with the material available, to make out all details of the antennule, but it appears to be segmented in precisely the same way as in *Cyclops*, namely of 17 segments with the hinge between segs. 14 and 15. I have not seen æsthetes in the proximal part. The information available as to the structure of the male antennule in *Cyclopina* is very unsatisfactory. The segmentation and distribution of æsthetes is worthy of further attention as likely to throw some light on the relation between *Cyclopina*, *Euryte* and *Cyclops*. I have failed to obtain material for this purpose. Leg 5 as in female. Leg 6 represented by 2 long setæ.

Distribution in Britain.

An estuarine and littoral species common in the estuaries of the east coast.

Scotland: Oban (Brady), Firths of Forth and Clyde (Scott).

Ireland: Lough Swilly (Brady).

England: Northumberland (Brady); Devon (Norman and Scott); Lancashire (Thompson); Norfolk (R. G.); Suffolk, Woodbridge (R. G., A. G. L.).

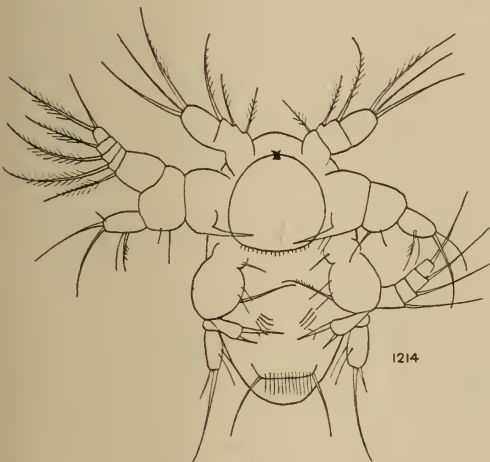
Distribution Abroad.

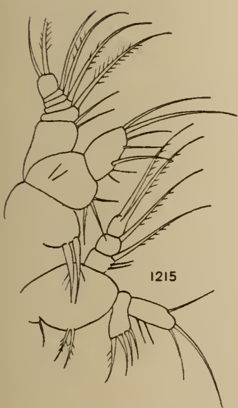
Norway (Sars).
France (Canu).
Germany, Kiel (Giesbrecht).
Mediterranean (Claus, Giesbrecht, Gourret).
Black Sea (Grebnitzky).
Franz Josef Land (Scott).
Grinnel Land (Sars).

Sars (1921) has distinguished from the commonly accepted *C. gracilis* a second species, *C. norvegica*, Boeck, which is characterized mainly by the form of the cephalothorax and the shorter furcal rami. Fruchtl (1923) has described a third form, *C. steueri*, which is also with

difficulty separable from *C. gracilis*. The status of these three species seems to be very obscure.

Claus's original description is insufficient for the exact form to be identified. Brady's figures (1878) leave it





FIGS. 1214–1216.—*Cyclopina.*

FIG. 1214.—Nauplius, *C. pygmæa*, stage I.
FIG. 1215.—Nauplius, antenna and mandible, stage II. *C. gracilis.*
FIG. 1216.—*C. gracilis*, Plymouth, furcal rami.

quite uncertain as to which form he was describing, while the detailed and excellent description of Giesbrecht (1882) seems to refer to *C. norvegica*. Brady's *Cyclops salinus*, which Sars regards as a synonym of

C. norvegica, cannot be regarded as sufficiently well described for comparison. Giesbrecht (1900) notes a difference in the length of the rami between Mediterranean and Baltic specimens, but does not otherwise distinguish them. There does not therefore appear to be any adequate description of the typical *C. gracilis*, unless that of Sars, given before he distinguished the two forms, can be regarded as such. Fruchtl (1923) has given a table showing the characters of all the species then known, from which the following table is compiled. It will be seen that the differences are so small that separation of the species must rest on the assumption that there is no local or individual variation. The only clear-cut differences are the presence of a fine frill on some of the abd. somites of *C. steueri*, and of 3 setæ instead of 2 on endopod 1 of the mandible palp. The latter distinction is, I believe, founded upon error, since Giesbrecht figures 3 setæ in the form from Kiel, and there are 3 in my own specimens. My own specimens also, while they appear to be referable to *C. norvegica*, if that species is to be upheld, differ from it in the form of leg 5, and in the relative lengths of the furcal setæ.

A specimen from Plymouth Sound, which I refer to Sars's typical form of *C. gracilis*, has the rami about 5 times as long as wide, but differs from Sars's figure in the relative lengths of the inner and outer furcal setæ. It seems that there is some justification for separating this form from the form described above. I therefore refer the latter to *C. norvegica*, but a revision of the group is very necessary, based on material adequate to estimate local and individual variation. The evidence seems to point to *C. norvegica* being a coastal and estuarine form, while the typical *C. gracilis* is marine.

Cyclopina norvegica.

	Body.		Furcal rami.			Furcal setæ.				Abdominal somites.				Ramus.
	Length.	Width.	Length.	L.: W.	Lateral seta.	1.	2.	3.	4.	1 + 2.	3.	4.	5.	
Woodbridge, ♀ . .	·58	..	73	3·25	46	79	240	360	120	..	..	..	..	..
,, ♀ . .	·62	..	66	3·3	40	78	226	355	118	43	26	20	15	25
,, ♀ . .	·61	328	69	3·15	37	78	220	..	115	..	..	37		25
,, ♂ . .	·46	..	46	2	37·5	83	264	..	132	..	..	..	..	..
C. gracilis.														
Plymouth, ♀ . . .	·6	332	95	5·0	35	67	230	320	113	..	..	..	..	..

	C. gracilis, ♀.	*C. norvegica*, ♀.	*C. steueri*, ♀.	*C. Norvegica*, ♀, Woodbridge.
Length . . .	·43–·65	·5	·41	·58–·62.
Genital somite . .	= Abd. soms. 3–5	= Abd. soms. 3–5	Longer than abd. som. 3 and 4	= Abd. soms. 3 and 4.
Abd. som. 3 . . .	Smooth	Smooth	With dissected hyaline frill	Smooth.
Length of furcal ramus compared with abdomen	Longer than soms. 4, 5	Little longer than 5	$1\frac{1}{2}$ times as long as 5. Lengths of soms. 3–5 and ramus: 29, 19, 19, 27	About $1\frac{1}{2}$ times as long as 5. Lengths of som. and furca: 26, 20, 15, 25.
Furcal ramus, length: width	About 4 times	Barely more than 3	$2\frac{1}{2}$ times	2·85–3·25 times.
Mandible palp, endopod 1	With 2 setæ	2 setæ	3 setæ	3 setæ.
Leg 5, seg. 2. . .	$1\frac{1}{2}$ times as long as wide. Inner side smooth	About twice as long as wide. Inner edge hairy	As *gracilis*. Both sides hairy	As *gracilis*. Both sides hairy.
Spines of leg 5 . .	Outer $\frac{1}{4}$ longer than inner	Outer twice as long as inner	Spines equal	Outer $1\frac{1}{2}$ times as long as inner.

CYCLOPIDÆ, Sars.

1913. Sars, Crust. Norway, VI, p. 22.

Somite of leg 1 united with cephalothorax ; antennule of female of 6–21 segments, that of the male of 17, or fewer, the hinge falling between segs. 14 and 15 ; antenna generally of 4 segments ; mandible palp reduced to a small papilla with 2 or 3 setæ, or absent ; maxillule with endopod and exopod reduced to a single undivided plate ; maxillipede with endopod reduced. Nauplius with seg. 1 of endopod of mandible forming a masticatory fork. Two egg-sacs borne laterally.*

Kiefer divides the family into Halicyclopinæ, Eucyclopinæ and Cyclopinæ ; but reasons have been given above (p. 8) for not accepting his association of *Euryte* and *Halicyclops*. In dealing with *Cyclops* below I shall attempt to justify rejecting also the subfamilies Eucyclopinæ and Cyclopinæ. We return, therefore, to the position adopted by Sars, of a series of genera or subgenera, the relation of which to one another is uncertain.

HALICYCLOPS, Norman.

1894. *Hemicyclops,* Claus, Arb. Zool. Inst. Wien, X, p. 348.
1903. *Halicyclops,* Norman, Ann. Mag. Nat. Hist. (7) XI, p. 368.
1913. ,, Sars, Crust. Norway, VI, p. 28.
1927. *Herouardia,* Labbé, Arch. Zool. Exp. LXVI, p. 191.

Furcal rami short ; antennule of 6 segments ; antennule of male with æsthetes on segs. 11 and 13. Antenna of 3 segments. Setæ of mandible palp very short. Maxillipede reduced. Leg 5 2-segmented, seg. 2 flattened, with 4 setæ or spines in female, and 5 in male. Nauplius with 2 separate ocelli.

Type : *H. æquoreus* (Fischer).

* In some aberrant species no egg sacs have been seen (p. 286).

Halicyclops æquoreus, Fischer.

(Figs. 1217–1244.)

1853. *Cyclops magniceps*, Lilljeborg, Crust. Ord. Trib. p. 204, fig.
1860. *C. æquoreus*, Fischer, Abh. Bayer. Acad. VIII, p. 654, figs.
1868. ,, Brady, Trans. N. H. Soc. Northd. III, p. 128, figs.
1872. *C. christianensis*, Boeck, Forh. Vid. Selsk. Christ. p. 43.
1878. *C. æquoreus*, Brady, Mon. Brit. Cop. I, p. 119, figs.
1901. ,, Lilljeborg, Svenska Akad. Handl. XXXV, p. 102, figs.
1902. *C. eboracensis*, Brady, Trans. H. N. Soc. Northd. XVI, p. 56, figs.
1908. *C. æquoreus*, Van Breemen, Tijds. Ned. Dierk. Verh. (2) X, p. 343, figs.
1913. *H. magniceps*, Sars, Crust. Norway, VI, p. 29, figs.
1928. *H. æquoreus*, Kiefer, Zool. Anz. LXXV, p. 219.

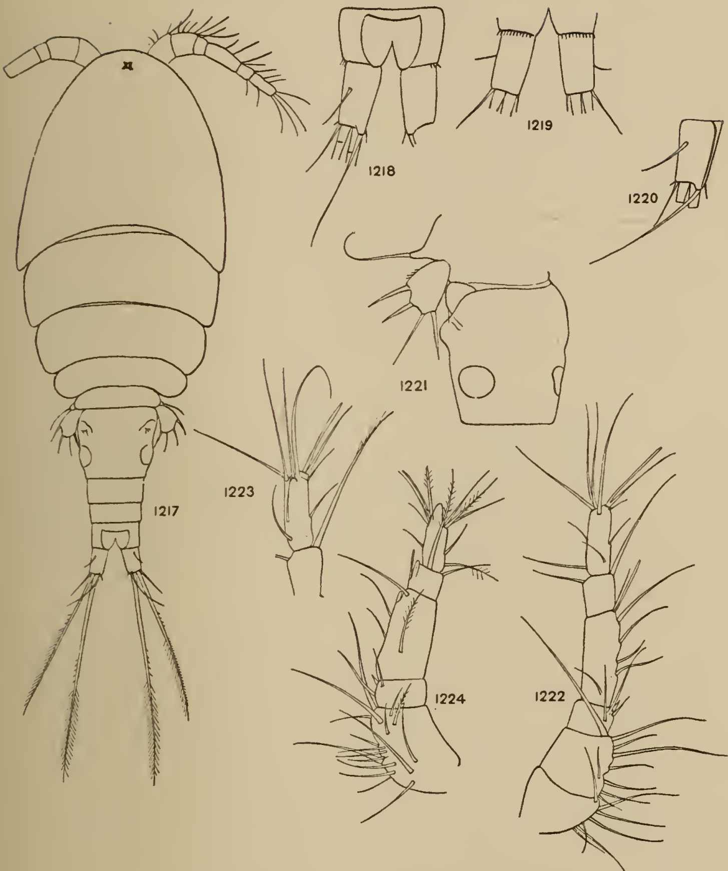
The correct name for this species has been in dispute. Lilljeborg's description of *C. magniceps* was so faulty that the species is not recognizable, and Fischer's name has been generally adopted. Lilljeborg himself (1901) relinquished all claim to priority for his name, so that Sars's reinstatement of it in 1913 cannot be supported (see Kiefer, 1928).

Female.—Length ·65–·73 mm.

Thorax broad, somewhat flattened, about twice as long as abdomen; cephalothorax generally broader than long. Genital somite little dilated, longer than wide; on each side posteriorly is a faintly marked "lateral disc."

Margins of abd. somites smooth; somite 5 generally deeply cleft ventrally, with a row of spinules at base of rami. Furcal rami about twice as long as wide; lateral seta rather long, inserted a little in front of middle (36–41%); inner apical seta very minute, sometimes apparently absent; dorsal seta very long, seated on a small protuberance; outer seta a little longer than ramus; seta 2 about half length of seta 3, with short prickles along outer edge, but feathered along inner side; seta 3 with widely spaced prickles at base, closely feathered distally. Antennule of 6 segments, of following lengths: 25, 23, 11, 34, 14, 25.

It is not easy to compare the antennule of *Halicyclops* with that of *Cyclops*, and the interpretations given by Claus, Mrázek and Burckhardt (1913) differ.



Figs. 1217–1224.—*Halicyclops æquoreus.*

Fig. 1217.—Female, dorsal.
Fig. 1218.—Furcal rami, dorsal.
Fig. 1219.—Furcal rami, ventral.
Fig. 1220.—Slightly oblique, showing ridge.
Fig. 1221.—Genital somite and leg 5.
Fig. 1222.—Antennule, female.
Fig. 1223.—Antennule, last segment.
Fig. 1224.—Antennule, male, copepodid V.

Neither of these schemes seems to be satisfactory, and it is more reasonable to set out with the assumption that the position of the æsthete on seg. 4 and of the spine on seg. 3 in *H. æquoreus* are points comparable to

Comparison of antennular segments in H. æquoreus *and* Cyclops.

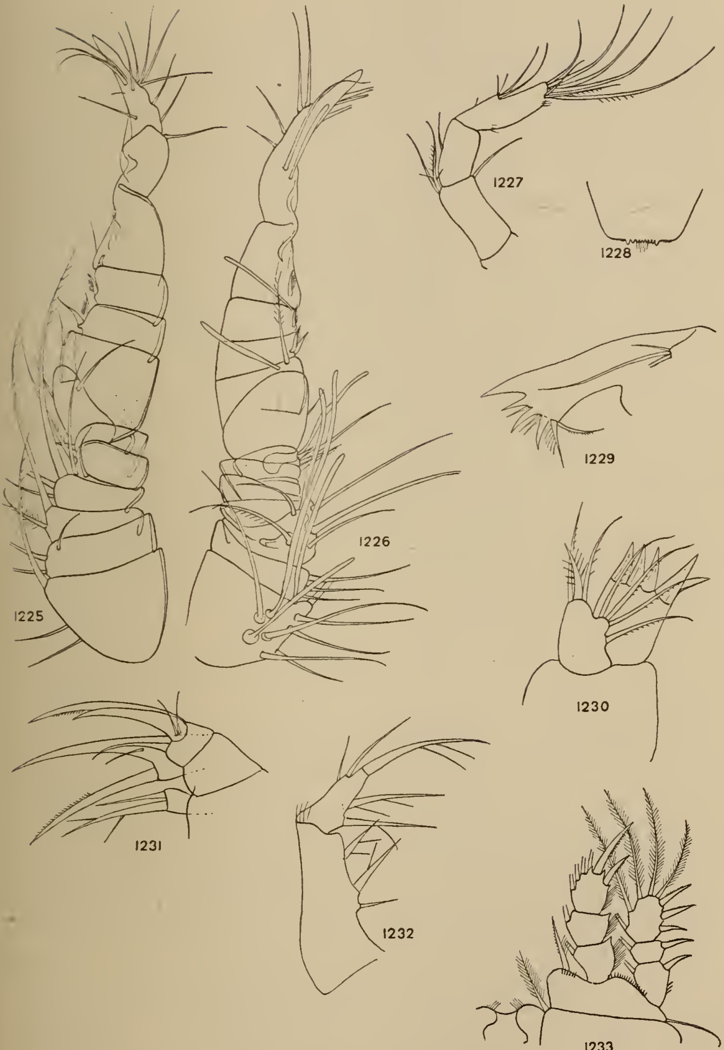
H. æquoreus.		1. *Cyclops.* Claus (1893).	2. *Cyclops.* Burckhardt (1913).	3. *Cyclops.*
Segments.	Number of setæ.			
1	8	1	1	1
2	11	2–4	2–4	2–4
3	3 + Sp.	5–7	5–6	5–6
4	6 + A	8–11	7–14	7–12
5	1 + 1	12–14	15	13–14
6	2 + 2 (6 + A)	15–17	16–17	15–17

segs. 12 and 6 in *Cyclops*. Column 3 shows the homologies of the segments so arrived at. In this scheme the numbers of setæ on the segments agree almost exactly. The following table shows how the antennule of *Halicyclops* may be derived from that of *Euryte* and *Cyclopina* :

Euryte . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Cyclopina littoralis .	1 2		3		4	5		6		7	8	9	10	11	12	13	14	15	16	17	18
Cyclopina gracilis .	1 2		3		4	5							6				7		8	9	10
Halicyclops æquoreus .	1			2		3							4				5			6	

In copepodid I the antennule has only 3 segments. Of these, the last 2 remain distinct, but seg. 1 divides to give rise to segs. 1–4, that is to say, it is equivalent to segs. 1–12 of *Cyclops* (Figs. 1241–1244).

Copepodid I . .		1			2	3
,, III . .	1		2		3	4
,, IV . .	1		2	3	4	5
,, V . .	1		2	3	4	5
Adult . . .	1	2	3	4	5	6



FIGS. 1225–1233.—*Halicyclops æquoreus.*

FIG. 1225.—Antennule, male adult, dorsal.
FIG. 1226.—Antennule, male adult, ventral.
FIG. 1227.—Antenna.
FIG. 1228.—Upper lip.
FIG. 1229.—Mandible.
FIG. 1230.—Maxillule.
FIG. 1231.—Maxilla, distal part.
FIG. 1232.—Maxillipede.
FIG. 1233.—Leg 1.

Antenna of 3 free segments only, segs. 3 and 4 being fused. Upper lip rather narrow, with about 9 small blunt teeth. Mandible with broad cutting edge, armed with relatively few teeth; exopod represented by a small papilla, bearing 3 setæ, of which the two longest are not much longer than the mandible itself. Maxillule with bilobed palp bearing 3 setæ on each lobe, and an anterior lateral seta, which possibly represents the exopod. Maxilla as in *Cyclops*, the endopod of only 2 distinct segments. Maxillipede very small and slender, of 2 segments; seg. 1 with 3 setæ, seg. 2 with 5.

Legs with rami 3-segmented, with spine-formula 3.4.4.3; uniting lamella smooth; endopods with 2.3.3.3 spines on seg. 3. Leg 4 endopod 3 about twice as long as wide, the inner apical spine longer than the segment, and nearly $1\frac{1}{2}$ times as long as the outer spine.

Leg 5, seg. 1 fused with somite and bearing a small outer seta; seg. 2 a flat plate, broadening distally, and bearing 3 short spines and a slender seta.

Egg-sacs closely pressed to abdomen.

Colour: Greyish-white; sometimes rather rosy red.

Male.—Length ·38–·45 mm.

Antennule in copepodid 5 of 5 segments, as in the female, the segments corresponding precisely in relative length, and very closely in number of setæ. It differs from that of the female in that seg. 3 is stouter, bears only 4 setæ instead of 6, and has a small blunt process on anterior face near end. Seg. 4 differs in having an æsthete and a blunt process.

The antennule of the adult has been variously interpreted. Canu described it first as of 12 segments, and later (1898) as having 13. Sars gives 11 segments, while Labbé (*Herouardia paradoxa*) figures and describes 10 only. It is by no means easy to determine the number exactly, and, on the ventral side, the proximal segments are almost inseparable. From the dorsal side it is possible to distinguish 14 segments in all, the hinge falling between segs. 12 and 13. Seg. 1 bears 3 very

long æsthetes, and another is found in the region corresponding to seg. 4. A fourth is situated at the end of the first section of the appendage, in the position corresponding to seg. 9 of the *Cyclops* antennule. It seems that some fusion of segments has occurred in the region of segs. 4 and 5. The middle section is swollen, and consists of 5 segments. Seg. 9 (seg. 11 of *Cyclops*) is enveloped on the anterior side by seg. 8, and bears on this side an æsthete and a seta. This æsthete is apparently not present in *Cyclops*. On its dorsal face this segment has the appearance of having a portion of itself divided off, and it is this part which is figured by Labbé (1927, figs. 164, 165) as a spinous process. Seg. 11 also bears an æsthete not represented in *Cyclops*. The terminal part is divided into two segments, the first of which bears a long æsthete. The last segment is produced into a long pointed process, and bears 10 setæ and an æsthete. The probable origin of the segments and their homologies with those of *Cyclops* is as follows :

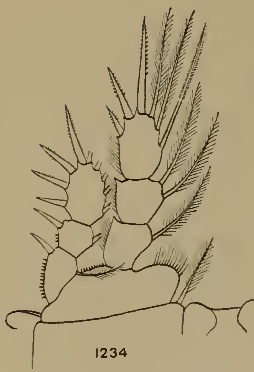
Cyclopid 5, ♂ . . .	1						2			3					4	5	
Adult . . .	1	2	3	4			5	6	7	8	9	10	11	12	13	14	
Cyclops . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Leg 5 of the same general form as in the female, but with an additional seta.

Leg 6 a plate with a strong inner spine and 2 slender setæ.

Nauplius (Figs. 1238–1240).

Body flattened, oval ; lateral ocelli of eye widely separated ; ventral surface of body with transverse row of fine hairs, a double row seen in one case. Exopod of antenna with middle segments ill defined and compressed ; mandible with very long, stiffly-feathered seta on basis.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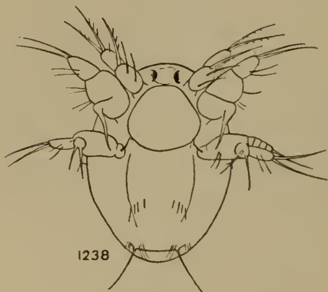
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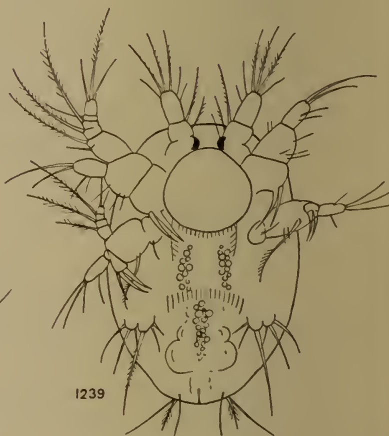
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Figs. 1234–1241.—*Halicyclops æquoreus.*

Fig. 1234.—Leg 2.
Fig. 1235.—Leg 4.
Fig. 1236.—Leg 5, female.
Fig. 1237.—Legs 5 and 6, male.
Fig. 1238.—Nauplius I.
Fig. 1239.—Nauplius IV.
Fig. 1240.—Mandible, nauplius.
Fig. 1241.—Antennule, copepodid I.

Variation.

As will be seen in the table (p. 26), the British specimens fall into two groups, distinguished by the form of the furcal rami and the length of the inner seta. In the one case the ramus is not much, if at all, longer than wide, and the inner seta is longer than the ramus, and in the other the ramus is about twice as long as wide, and the inner seta obsolete, or very small. The same differences appear in published descriptions of *H. æquoreus*, but have not been specially noted. The short form of ramus is figured by Canu, Marsh, Claus and Brady (1892), while the long ramus appears in figures by Lilljeborg, Sars and Brady (1878). In specimens with short ramus the anal somite is deeply cleft, but this is not a distinguishing character, since it may also be seen in those with long rami. It is upon just such differences in the rami that other species of the genus are mainly founded, and the question arises whether any of them should be maintained. Two of them, H. *sinensis*, Kiefer (=*C. æquoreus*, Burckhardt, 1913), and *H. tenuispina*, Sewell, have certain positive distinguishing characters, for example, the form of the antennule in the former, and may be accepted; but *H. propinquus*, Sars, and *H. thermophilus*, Kiefer, are very doubtful. These two differ, according to Kiefer, in the length of furcal rami, form of setæ of swimming-legs, and length of spines on leg 4, endopod 3. The difference in the rami is much less than that between the two British forms, and scarcely greater than between two individuals from the same sample at Plymouth (see table, Nos. 5 and 7). The only difference which seems, for the moment, to be outside the range of individual variation is the form of the setæ of the legs, and this may have no more significance than it has in the case of *Cyclops vernalis* and *robustus*. I therefore regard these species as identical.

It seems to be equally difficult to separate *H. propinquus* from *H. æquoreus*. There is no difference whatever between the rami of *H. proqinquus* and the

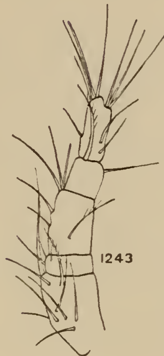
Halicyclops æquoreus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end 3.
1. Norfolk	·65	400	62	2	41·5	49	306	620	..	1·82	144	133
2. Woodbridge	·66	425	53	1·92	36	58	273	500	18	1·5	162	162
3. Fowey	·69	350	47	1·82	45	51	290	520	17	1·54	134	140
4. Seaton Sluice	·63	395	63	2·3	44	51	300	570	..	..	..	..
5. Bembridge	·73	370	53	1·94	42	40	260	520	..	1·85	148	140
6. Morar, Scotland	·68	350	47	1·72	..	44	293	540	15	1·68	136	136

Halicyclops æquoreus propinquus.

1. Wells, Norfolk	·65	385	32·5	1·08	46	34	260	..	34	1·77	126	104
2. Muckfleet, Norfolk	·72	360	35	1·08	44	42	221	..	26	1·7	142	123
3. Plymouth	·57	440	37	1·07	39	39	300	630	49	1·73	126	106
4.	·53	450	37·5	1·00	50	42	300	640	42	1·8	135	104
5.	·61	410	34·5	1·08	39	47	280	580	49	1·44	147	108
6.	·60	400	35	1·18	39	42	250	548	42	1·38	128	96
7.	·58	450	43	1·3	40	53	305	650	47	1·85	104	95
8.	·66	390	39	1·25	36·5	52	265	560	38	1·42	130	108
9. Plymstock	·57	405	38·5	1·4	43	53	280	620	37	1·62	129	100

1242



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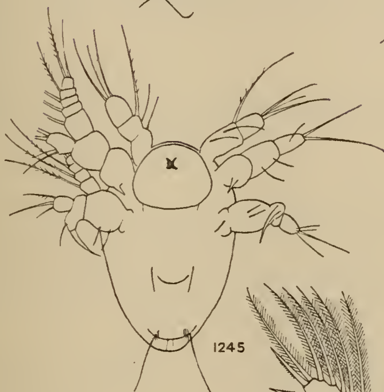

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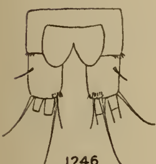

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Figs. 1242–1245.—*Halicyclops æquoreus.*
Fig. 1242.—Antennule, copepodid III.
Fig. 1243.—Antennule, copepodid IV.
Fig. 1244.—Antennule, copepodid V.
Fig. 1245.—Nauplius of *Euryte longicauda.*

Figs. 1246, 1247.—*H. æ. propinquus.*
Fig. 1246.—Furcal rami, dorsal. Fig. 1247.—Leg 4.

British form with short rami. There is a small difference in leg 4, endopod 3. This segment is considerably narrower in *H. æquoreus*, and the spines are more unequal, but there is much variation in British specimens, and the difference may almost disappear. In my own opinion no distinction is possible between the two forms, and I regard *H. propinquus* as nothing more than a

manifestation of local variability, found equally in this country and in the tropics. A somewhat similar case is that of *Artemia salina*, which, owing to the great range of variation in length of rami, more or less in accordance with salinity of habitat, was at one time divided into a number of species, but is now treated as one.

At the same time, in this as in other cases, it may be of advantage to retain, at least provisionally, a separate name for each of the two forms, and I have therefore applied Sars's name to the form with short ramus as a subspecies.

Halicyclops æquoreus propinquus, Sars.

(Figs. 1246–1247.)

1892. *Cyclops æquoreus*, Canu, Trav. Lab. Wim. VI, p. 184, figs.
? 1893. *Hemicyclops æquoreus*, Claus, Arb. Z. Inst. Wien, X, p. 348, figs.
1905. *H. propinquus*, Sars, Zool. Jahrb. XXI, p. 395, figs.
1913. *Halicyclops æquoreus*, Marsh, Smiths. Misc. Coll. LXI, p. 18, figs.
1929. *H. thermophilus*, Kiefer, Zool. Anz. LXXXIV, p. 46, figs.
1932. ,, Kiefer, Arch. Naturg. N.F. I, p. 236, figs.

Female.—Length ·53–·72 mm.

Furcal rami generally scarcely longer than wide, variable, in some cases nearly $1\frac{1}{2}$ times as long as wide; inner apical seta usually longer than ramus. Dorsal seta very long, inserted on a papilla, at the base of which is a short row of spinules; lateral seta very short. In all other respects as in typical form, but leg 4 endopod 3 sometimes less than $1\frac{1}{2}$ times as long as wide, and apical spines generally nearly equal.

Distribution in Britain.

In view of the fact that no distinction has hitherto been drawn between these two forms in Europe, it is impossible to give their distribution separately.

Brady, Scott and Scourfield have recorded this species from a number of localities round our coasts, from the Orkneys in the north to the Scilly Islands in the south,

and also from Wales and Ireland. It is probably to be found wherever there are brackish coastal pools with a little vegetation. I have taken it myself in many places, particularly in Norfolk, from January to October, and it appears to be perennial. It requires water of a salinity approaching that of sea-water, and is commonly associated with *Mesochra lilljeborgii*. *H. a. propinquus* is recorded from fresh water by Marsh, and from a hot spring in Java by Kiefer.

Distribution Abroad.

Norway (Sars).
Sweden (Lilljeborg).
Finland (Martens).
Holland (Van Breemen, De Lint).
Germany: North Sea coast (Klie).
France (Canu).
Caspian Sea (Tschugunoff, Rylov).
Aral Sea (Meissner).
Algeria: In inland salt waters (Richard, Roy and Gauthier).
Egypt (Daday, R. G.).
Madeira (Fischer).
Dalmatia (Brehm).
United States and Panama (Marsh).
Chatham Islands (Sars): New Zealand (Thomson).
Java (Kiefer).

CYCLOPS, O. F. Müller.

1776. *Cyclops* (part), O. F. Müller, Zool. Dan. Prodr. p. 201.
1892. ,, Schmeil, Bibl. Zool. Heft XI, p. 15.
1929. *Eucyclopinæ* and *Cyclopinæ*, Kiefer, Tierreich, Lief LIII, pp. 26, 45.

Somite of leg 1 united with cephalothorax; genital somite with large median receptaculum seminis; antennule of female of 6–18 segments, in male of 17 segments, with hinge between segs. 14 and 15; antennule of female with 1 small æsthete on seg. 12 or its equivalent, that of male with æsthetes on other segments,

but none on segs. 10–12 ; mandible palp vestigial,* with 3 setæ, of which one is very short ; endopod of maxillipede of 2 distinct segments ; legs with rami generally of 3 segments ; leg 5 of 2 or 1 segment, cylindrical or plate-like, with not more than 3 apical setæ.

Type.—*C. strenuus*, Fischer.

Schmeil, in 1892, recognized only 23 species of *Cyclops* as occurring in Germany ; but this number has been greatly increased, partly by the establishment as species of some forms which he rejected as varieties, and partly by description of wholly new species. Kiefer (1929) gives 58 European species, though the validity of some of them is doubtful. The most important additions are those from underground waters, which have been described by Graeter, Chappuis and Kiefer. The total number of species included in Kiefer's volume is 137, and 32 have been added since then (March, 1932). It is therefore of some practical advantage to divide up this large genus, but difficult to do so satisfactorily.

The first attempt at such a division was that of Rehberg (1880), who divided the species into three groups according to their larval development. The first contained only *C. affinis* ; the second *C. fimbriatus* and *C. phaleratus* ; the third all the rest.

J. A. Frič (1882), also making use of larval characters, set up two groups :

Dolichopoda.—Nauplius oval ; all legs natatory ; mandible with long natatory branch ; antennal gland straight :

C. viridis, etc.

Brachypoda.—Nauplius compressed ; mandible crooked, serving only for feeding :

C. serrulatus.
C. fimbriatus.
C. phaleratus.

* Absent in *C. demetiensis*.

Fric̆'s system has received no recognition, but seems to express a fundamental truth.

Vosseler (1886) arranged the species in groups, primarily based upon the structure of leg 5 and of the male antennule, but without defining subgenera. His arrangement holds good, in essentials, to this day.

Schmeil (1892) also treated all species as in one genus. He adopted Vosseler's primary divisions, and subdivided these into a series of 8 groups. Very little adjustment is needed to make Schmeil's groups agree with the latest system of Kiefer.

It was Claus (1893) who first actually established new subgenera. Although Claus's system has the merit of precision, it is, on the whole, inferior to that of Schmeil in that he did not recognize any primary grouping, or the existence of smaller groups.

Mrázek (1893) strongly criticized Claus's division into subgenera, pointing out, quite rightly, not only the transitional character of some species, but also the unity of the whole in respect to primary characters, such as genital organs and mouth-parts. His views as to phylogeny were summarized in a table of descent (1894).

The views of Schmeil and Mrázek prevailed for many years, and Claus's subgenera were adopted only by E. B. Forbes (1897), who introduced two more, *Homocyclops* and *Orthocyclops*.

Graeter (1903) gave the names Trifida and Bifida to the primary divisions of Vosseler and Schmeil; but divided the latter again into two groups, Chætophora and Acanthophora. The former, in which the apex of leg 5 bears 2 setæ, corresponds to the *C. leuckarti*-group of Schmeil, together with *C. gracilis*, while the latter, in which the inner seta is reduced to a spine, were again subdivided according to the position of this spine. Graeter's system is, in some respects, an advance on that of Schmeil, but his reliance upon the importance of the position of the spine on leg 5 led him to a grouping

Claus.	Sars.	Graeter.	Schmeil.	Kiefer.
		TRIFIDA.	Groups.	Eucyclopinæ.
Macrocyclops *Eucyclops*	*Pachycyclops* *Leptocyclops*	*fuscus, albidus* *serrulatus, prasinus*	6. *fuscus, albidus* 7. *serrulatus, prasinus*	*Macrocyclops* *Eucyclops* s. g., *Eucyclops* s. str. ,, s. g., *Tropocyclops* [*Thaumasiocyclops* (1930)]
Paracyclops *Heterocyclops*	*Platycyclops*	*affinis, fimbriatus phaleratus*	8. *affinis, fimbriatus phaleratus*	*Paracyclops* *Ectocyclops*
		BIFIDA.		Cyclopinæ.
Cyclops	*Cyclops*	Acanthophora (*a*) *Strenuus, viridis varicans* (b) *vernalis, bisetosus, diaphanus, bicolor, etc.*	1. *strenuus, insignis* 2. *bicuspidatus* (a) *bicuspidatus, languidus* (b) *vernalis, bisetosus* (c) *viridis*	*Cyclops* s. g., *Cyclops* s. str. ,, *Diacyclops* ,, *Acanthocyclops*
Microcyclops	*Cryptocyclops*		3. *gracilis, diaphanus* 4. *varicans, bicolor*	,, *Megacyclops* ,, *Metacyclops* ,, *Microcyclops* [*Bryocyclops*] [*Allocyclops* (1932)]
Cyclops (part)	*Mesocyclops*	*Chætophora* (a) *leuckarti* (b) *oithonoides, gracilis*	5. *leuckarti, oithonoides*	*Mesocyclops* s. g., *Mesocyclops* s. str. ,, *Thermocyclops* [*Orthocyclops*]

of the species of "Acanthophora" which is quite unnatural, and separated closely allied species, *e.g. C. varicans* from *C. bicolor*, and *viridis* from *vernalis* (Graeter, 1903, p. 462).

Sars (1913-1915) introduced a system of families and genera which was an advance on all previous systems in its precision, but was still inferior to that of Schmeil in ignoring the existence of any primary divisions within the old genus *Cyclops*. His genera corresponded almost exactly to those of Claus, but he introduced entirely new names—an injustice to Claus and a burden to his successors. Still more troublesome to his successors was his exhumation of nine of Koch's names which had been decently interred by Claus and Schmeil.

At a later date (1927) Sars introduced two new genera, *Cryptocyclops* and *Afrocyclops*. The former corresponds to *Microcyclops*, Claus, while the latter is not separable from *Eucyclops*.

Finally (1928, 1929) Kiefer reviewed the whole subject, reinstated, as far as possible, the generic names of Claus in place of those of Sars, and introduced a new system of families and subfamilies which is intended to group the genera in phylogenetic series. The actual grouping of the species in Kiefer's system is almost exactly the same as that of Schmeil. Having regard to the immense increase of knowledge during the thirty-seven years between the appearance of the two works, no higher tribute could have been paid to the soundness of Schmeil's judgment.

There are two main requirements of any system—that it should be practical, not only for the specialist, but still more for the non-specialist; and that it shall, as far as may be, reflect current ideas of phylogeny. Both these objects tend to be defeated by excessive splitting of genera and species. The giving of a name, together with a definition, generally implies a clear-cut division in an evolutionary series, and it is the aim of systematists to discover and to mark such divisions; but, where they can only be marked by the most trivial

of differences, the break is over-emphasized and the essential unity is obscured. It seems more in accordance with the evolutionary outlook if, in such a case as that of the genus *Cyclops*, we endeavour to emphasize this unity, rather than the diversity, and to introduce as few group-divisions as may be effective for practical purposes. It must be remembered that fresh-water Copepods are receiving attention from helminthologists and others as the intermediate hosts of parasitic "worms," and it will probably be an appreciated convenience if the specialist can continue to give to the name *Cyclops* its old meaning. I feel myself that the framework of Schmeil's system is adequate for our present use, and that the expression "*leuckarti*-group" is just as scientific, and more illuminating, than the generic name *Mesocyclops*.

The following scheme is intended to preserve as far as possible the wide use of the name *Cyclops*, while making clear the diverging lines within it, and at the same time providing a convenient frame of reference for the species. It differs only from Kiefer's system in reducing his genera to subgenera, and in abandoning some of his subgenera. Further justification for this step will be given under the head of the separate subgenera.

Within the section Bifida it does not seem advisable to propose any sectional division, as we are quite in the dark as to the relationship of the many peculiar subterranean forms, and of some of the forms included in the *minutus*-group. Graeter's Chætophora and Acanthophora implies a cleavage between *Mesocyclops* and the rest of the depth of which I am not convinced.

There is one serious inconvenience in reverting to the extended use of the genus *Cyclops*. Since the establishment of genera within it has been generally accepted, the same specific name has, in some cases, been used for different species. If, however, all these genera are treated as subgenera of *Cyclops*, some of these names will have to be changed. Since the validity of these

genera is, and will probably remain, a matter of personal conviction, it is desirable that those who describe new species in future will bear this point in mind.

I am well aware that the course I have taken will be regarded by some specialists as reactionary and out of accord with the "new school" of thought, but I am not convinced that novelty is necessarily the same thing as progress, or that specialists are always the best judges of the general utility of their work.

CYCLOPS.

Section I. Trifida, Graeter.

Certain of the setæ of the male antennule modified into long cylindrical æsthetes (see Fig. 1319) ; leg 5 with 3 apical setæ or spines.

Subsection 1. Polyarthra.

Leg 5 normally 2-segmented ; antennule of female of 17 segments ; furcal rami short, without lateral denticles. Nauplius not flattened, exopod of antenna without marked compression of middle segments ; basis of mandible with long inner seta.

Subgenus *Macrocyclops*, Claus.

Subsection 2. Oligarthra.

Leg 5 unsegmented ; antennule of female of 12, or less, segments ; furcal rami generally with lateral, or dorsal, row of denticles. Nauplius generally flattened ; exopod of antenna with long slender terminal segment and middle segments compressed.

Subgenus *Tropocyclops*, Kiefer.
,, *Eucyclops*, Claus.
,, *Paracyclops*, Claus.
,, *Ectocyclops*, Brady.

Section II. Bifida, Graeter.

Male antennule with normal setæ, and æsthetes in addition on segs. 1, 4, 9; leg 5 with less than 3 apical setæ or spines, rarely reduced to a papilla bearing 3 setæ, one of which represents the seta of seg. 1.

Subgenus *Cyclops*, O.F.M. s.str.
,, *Acanthocyclops*, Kiefer.
,, *Microcyclops*, Claus.
,, *Bryocyclops*, Kiefer.
,, *Orthocyclops*, Forbes.
,, *Mesocyclops*, Sars.

Key to Subgenera of Cyclops.

1. Apex of leg 5 with 3 setæ or spines* . . . Trifida. 2.
   Apex of leg with less than 3 . . . Bifida. 6.
2. Leg 5 of 2 segments . . . . . *Macrocyclops*.
   Leg 5 unsegmented . . . . 3.
3. Leg 5 obsolete, the 3 spines or setæ springing directly from th. som. 5. Body flattened . . . *Ectocyclops*.
   Leg 5 a small plate with inner spine and 2 outer setæ . 4.
4. Antennule long and slender of 12 segments, with hyaline membrane or spinules on seg. 12 . . . . 5.
   Antennule short, of 11 or less segments . . *Paracyclops*.
5. Furcal rami long and slender, with denticles on outer margin . . . . *Eucyclops*.
   Furcal rami short, without outer spinules; receptaculum of peculiar form . . . . . *Tropocyclops*.
6. Antennule with hyaline membrane; leg 5 of 2 segments, seg. 2 with 2 long apical setæ; receptaculum hammer-shaped . . . . *Mesocyclops*.
   Antennule rarely with hyaline membrane; leg 5 of 1 or 2 segments, seg. 2 with apical seta only or with apical seta and inner spine; receptaculum rarely hammer-shaped . 7.
7. Antennule seg. 17 with row of spinules; exopod 3 of legs 1–4 with 5 setæ; leg 5 seg. 2 with large inner spine in middle of segment; furcal rami with dorsal ridge . *Cyclops* s. str.
   Antennule without spinules; exopod 3 usually with 4 setæ; leg 5 seg. 2 with inner spine near apex; rami without dorsal ridge . . . . . . *Acanthocyclops*.
   Antennule of less than 17 segments; rami of legs 2-segmented; leg 5 of 1 segment or vestigial . *Microcyclops*.

* Certain species included in *Microcyclops* (e. g. *C. demetiensis*) have 3 setæ springing together from the margin of the somite. In those cases the two inner setæ represent the two apical setæ of seg. 2.

The Larval Stages of Cyclops.

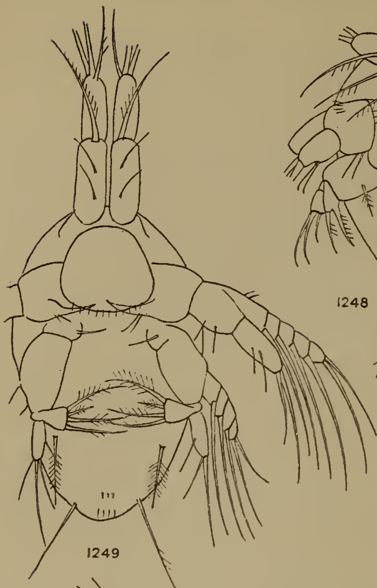
The Nauplius.

(Figs. 1248–1256.)

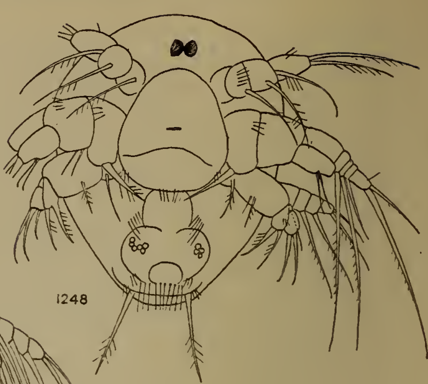
The structure of the nauplius in *Cyclops* may be taken as typical of that of the Cyclopoida as a whole, apart from the semiparasitic forms, in which the appendages may be much more simple. The nauplius shows no segmentation of the body, apart from a distinction between thorax and abdomen, which makes its appearance in stage 3. Even in stage 5, when the somites of legs 1 and 2 are clearly marked beneath the skin, the cuticle of the nauplius itself shows no trace of segmentation. It is evident that the body of the nauplius, as such, is not at all affected by the appearance of rudiments of appendages behind the mandible in preparation for the next step in ontogeny.

The furcal setæ never show the asymmetry characteristic of the Calanoida. The appendages closely resemble those of the Calanoida. The antenna has the exopod generally more fully developed and flexible than in Calanoida, the distal segments not being shortened, and the coxa always has a strong masticatory spine, which is represented in the latter by a comparatively small spine. The mandible, until stage 5, lacks the coxal masticatory process of the Calanoida, and the endopod is peculiarly modified. The endopod is 2-segmented (unsegmented in Calanoida), and seg. 1 has a large inner triangular process armed with 2–4 long curved spines which seem to have the function of conveying food to the mouth. This plate is actually a process of seg. 1, but has the appearance of being distinct from it and jointed to the basis. In *Acartia* the unsegmented endopod has an inner lobe bearing 4 spines, which, though not in any way separated from the endopod, seems to correspond to this plate.

In *Cyclops* the rudiments of maxilla and maxillipede are almost indistinguishable in the nauplius. In stage 5 the maxillipedes are represented by a pair of conical



1249



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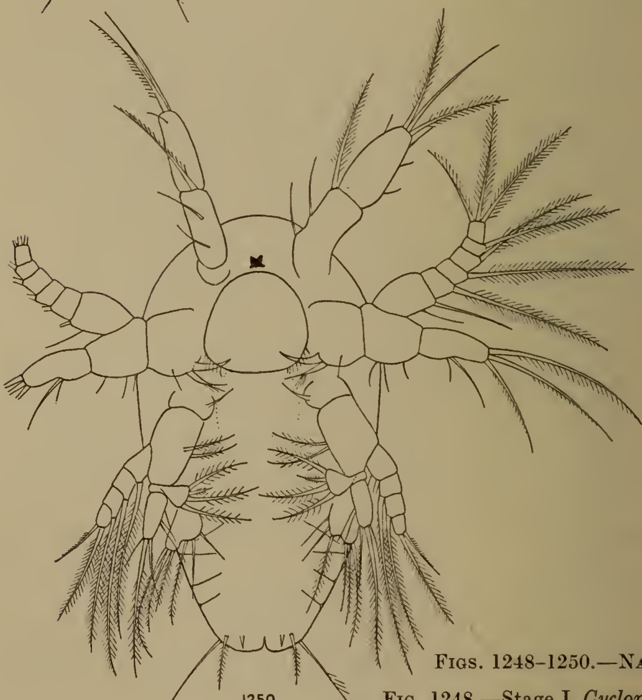


1250

Figs. 1248–1250.—Nauplii.

Fig. 1248.—Stage I, *Cyclops agilis*.
Fig. 1249.—Stage II, *C. strenuus*.
Fig. 1250.—Stage IV, *C. strenuus*.

projections near the middle line, and the maxilla as a pair of very faintly marked, transverse elevations lying outside the maxillipedes, and partly covered by the maxillules. In the Calanoida these appendages are quite large rudiments in the last nauplius. The rudiments of legs 1 and 2, though quite obvious in stage 5, are never so prominent as in Calanoida.

In some, and perhaps most, *Cyclops* there are rows of fine hairs on the ventral surface of the body, the arrangement of which may be characteristic of the species. These hairs are, however, very difficult to see in preserved material, and cannot easily be used for determination of species. They seem to bound an area behind the mouth in which the masticatory spines of the mandible work.

Although the general outlines of the development of *Cyclops* were well established by Claus as long ago as 1858, it was not till 1925 that it was followed in exact detail by Dietrich. Since that time the development of a number of species has been described, by Manfredi, Walter, Ziegelmayer and Amelina. Dietrich's account is excellent. He gives accurate figures, a full account of the changes in the appendages, and lays particular stress on his discovery that there are 5 nauplius stages only, as compared with 6 in *Diaptomus*. Manfredi, whose work is accurate and trustworthy, confirms Dietrich's conclusion; but both Walter and Ziegelmayer claim that there are 6 stages. Unfortunately they do not agree together as to where Dietrich was wrong, Walter finding an additional stage between 4 and 5, and Ziegelmayer an additional "orthonauplius." Ziegelmayer's work need not be seriously considered, since it is clear that he was dealing indiscriminately with nauplii of two or more species. Walter's conclusion cannot be disregarded. It is, on theoretical grounds, to be expected that *Cyclops* should have 6 stages, since that is the number found in *Oithona* (Oberg, 1906; Murphy, 1923), and there is reason for supposing that *Ergasilus* has the same number. On the other hand,

Amelina (1927), well aware that this point was in dispute, and having followed individual nauplii in cultures, has definitely stated that there are 5 stages only. Gelmini (1928) also states that there are 5 stages in *C. leuckarti.*

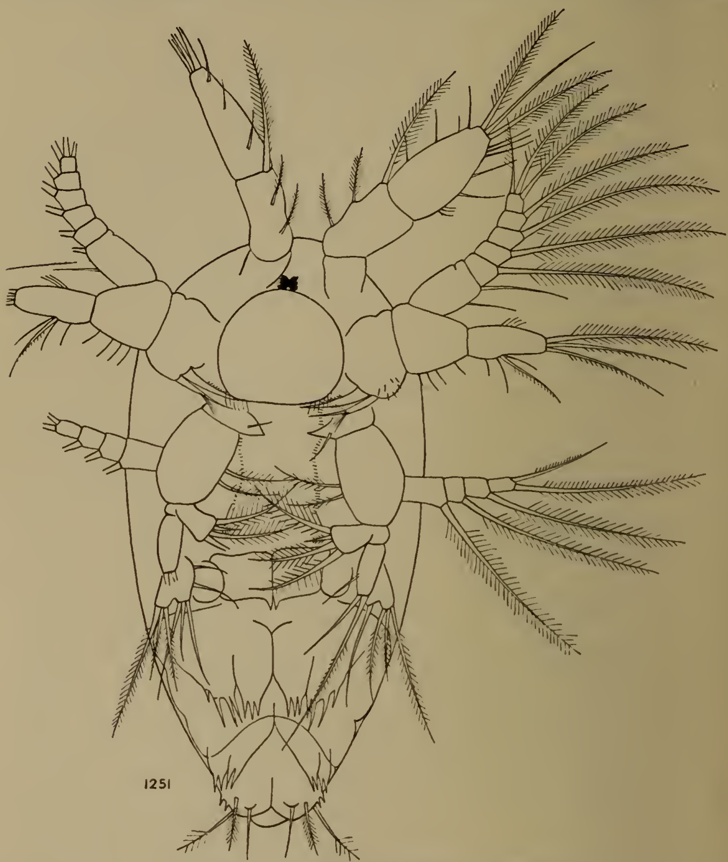
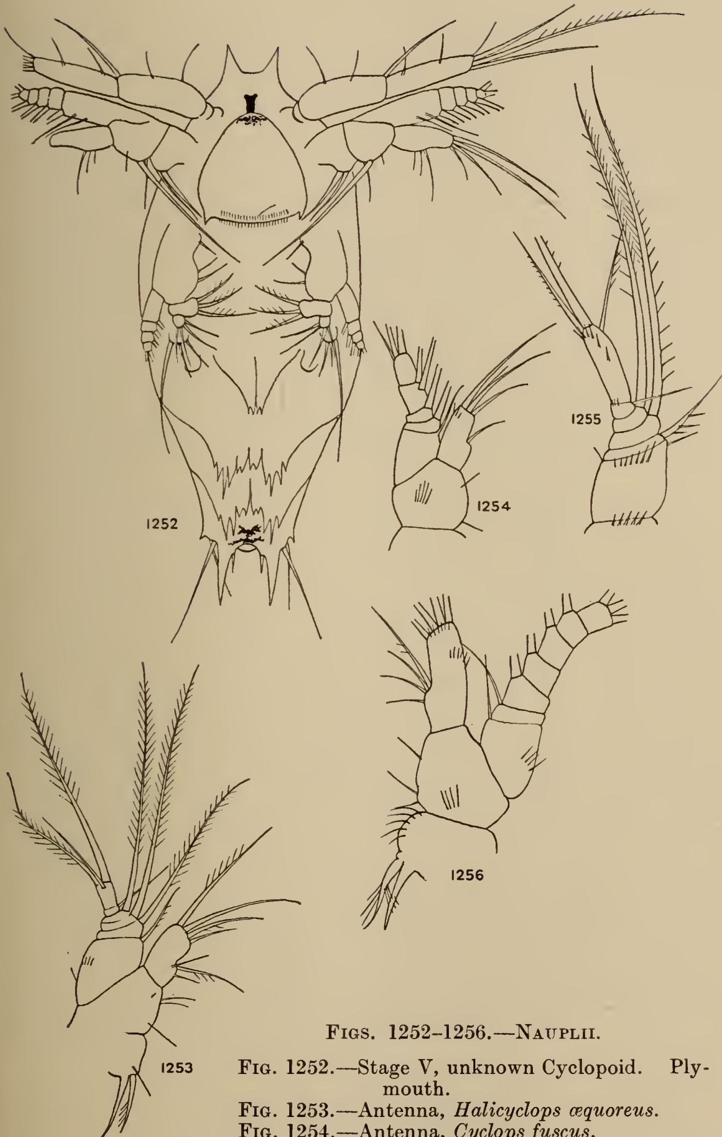


Fig. 1251.—Nauplius, stage V, *C. strenuus.*

Ewers (1929) states that there are 6 stages, but without offering evidence, or giving the characters of the additional stage. Her preliminary paper has not been followed by a complete account.

I have not myself followed the changes in isolated individuals, and feel some doubt as to the desirability



FIGS. 1252–1256.—NAUPLII.

FIG. 1252.—Stage V, unknown Cyclopoid. Plymouth.
FIG. 1253.—Antenna, *Halicyclops æquoreus.*
FIG. 1254.—Antenna, *Cyclops fuscus.*
FIG. 1255.—Antenna, *C. serrulatus,* exopod only.
FIG. 1256.—Antenna, *C. strenuus.*

Nauplius Stages. Cyclops strenuus.

	I.	II.	III.	IV.	V.
Length, calculated, growth factor 1·26	..	·21	·26	·33	·4
Length, actual, average	·169	·20	·23	·3	·39
Furcal setæ, pairs	1	1	2	2 + pair of small spines	3
Antennule, apical setæ	2	3	3	3	3
Mandible, spines on masticatory process	2	4	4	4	4
Maxillule	..	1 seta	1 seta	Bilobed, 6 or 7 setæ	7 or 8
Legs 1 and 2	..	..	..	..	Visible as rudiments.

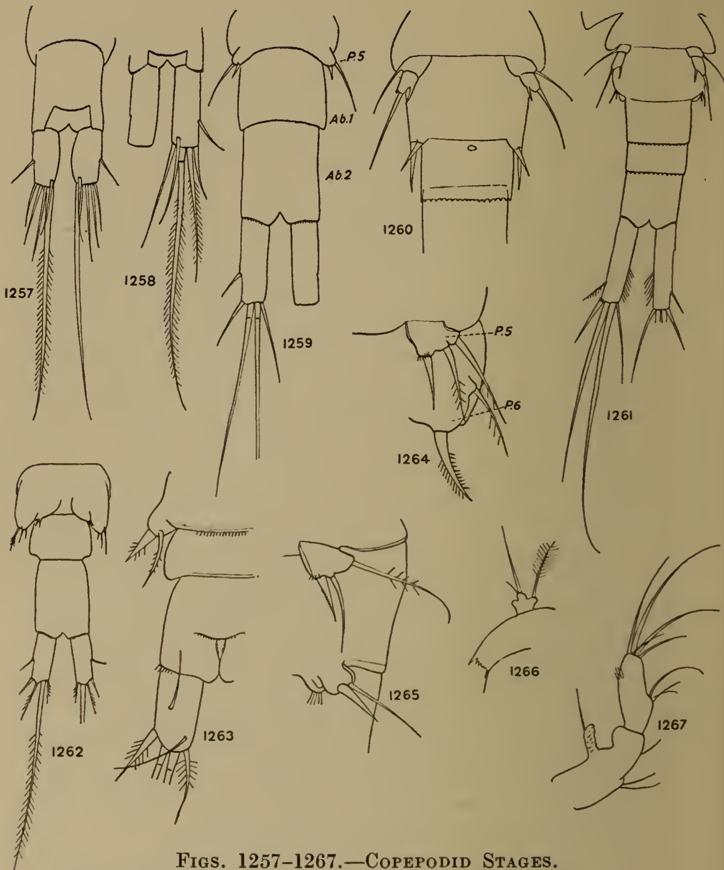
of doing so. Amelina notes that specimens bred in cultures were markedly smaller than in nature, and it is certain that Decapod larvæ are liable to disturbance of the normal course of development in cultures. I have therefore only used material taken from natural conditions. In the case of *C. strenuus*, of which I have had abundant material, I believe that Dietrich and Amelina are right, and that there are 5 stages. The characters of these stages are given below. On the other hand, it is possible to find differences between individuals in stage 4, which might be interpreted as proving an additional moult. The differences are exceedingly small, consisting only in the presence of an additional seta on the maxillule and a deepening of the notch on the appendage. The difference in size between these and the other individuals of stage 4 is so small as to make a moult improbable, while, assuming a growth-factor of about 1·26, there is not room for more than 3 stages between stage 1 and stage 5. There is great individual variation in size, and I believe that the apparent extra stage is accounted for by slight variation in structure at stage 4.

The nauplius of *Cyclops* does not, on the whole, give much help in the classification of the species. While the Oligarthra group of the Trifida possess in common a type of nauplius which is readily distinguishable by the form of the antenna, there is no possibility of separating the rest of the species into groups in this way. It is possible, as has been shown by Amelina, Manfredi and Ewers, to distinguish the nauplii of different species, and Amelina and Ewers give tables for the determination of certain species. The differences are, however, very small and difficult to observe, and the fact of their existence has a theoretical rather than a practical interest.

Copepodid Stages.

(Figs. 1257–1267.)

The post-naupliar development of *Cyclops* was fully described by Claus (1893), and has been dealt with since



FIGS. 1257–1267.—COPEPODID STAGES.

FIG. 1257.—Furcal rami, stage I, *Cyclops strenuus.*
FIG. 1258.—Furcal rami, stage II, *C. strenuus.*
FIG. 1259.—Furcal rami and abdomen, stage III, *C. strenuus.*
FIG. 1260.—Legs 5 and 6, stage IV, *C. strenuus.*
FIG. 1261.—Leg 5 and abdomen, female, stage V, *C. strenuus.*
FIG. 1262.—Leg 3 and abdomen, stage II, *C. vernalis.*
FIG. 1263.—Leg 6 and abdomen, stage IV, *C. fimbriatus.*
FIG. 1264.—Legs 5 and 6, female, stage V, *C. fimbriatus.*
FIG. 1265.—Legs 5 and 6, male, stage V, *C. fimbriatus.*
FIG. 1266.—Mandible, stage I, *C. strenuus.*
FIG. 1267.—Antenna, stage I, *C. strenuus.*

Copepodid Stages. Cyclops strenuus abyssorum.

Stage.	Length.	Segs. in antennule.	Leg 1.		Leg 2.		Leg 3.		Leg 4.		Leg 5.		Somites of "abdomen."	Total body somites.
			Somite.	Segs. in rami.	Somite.	Segs. in ramus.	Somite.	Segs. in ramus.	Somite.	Segs. in ramus.	Somite.	Segs.		
I.	·47	6	Free	1	Free	1	Free	Rud.	Free	..	..	..	1	5
II.	·6	7	,,	2	,,	2	,,	1	,,	Rud.	Free	..	1	6
III.	·75	9	,,	2	,,	2	,,	2	,,	1	,,	..	2	7
IV. ♀	1·0	10 (♂ 9 or 10)	,,	2	,,	2	,,	2	,,	2	,,	2	3	8
V. ♀	1·15	11 (♂ 10)	,,	3	,,	3	,,	3	,,	3	,,	2	4	9

by other authors (Manfredi, 1923; Ziegelmayer, 1925; Lucks, 1928; Gelmini, 1928).

There are 5 copepodid stages, as in the Calanoida, and development follows much the same course as in the latter (see Vol. I, p. 122). The characters of the different stages are summarized in the table on p. 45.

In stage I the somites of legs 1–4 are distinct, but the last somite represents both abdomen and somite of leg 5. With each moult a new somite is separated from this region. In stage V there are 4 free somites in the abdomen, and, at the next moult, the first two reunite, in the female, to form the genital somite, and a new somite is separated behind.

The furcal setæ pass through transformation similar to that in Calanoida. In stage I the innermost (seta 4) is very much the longest, the other 3 being short and slender (Fig. 1257). None are jointed at the base. The arrangement recalls that of the adult in *Ergasilus*. In stage II seta 3 is the longest, and is jointed at base (Fig. 1258). The adult proportions of the setæ appear in stage III.

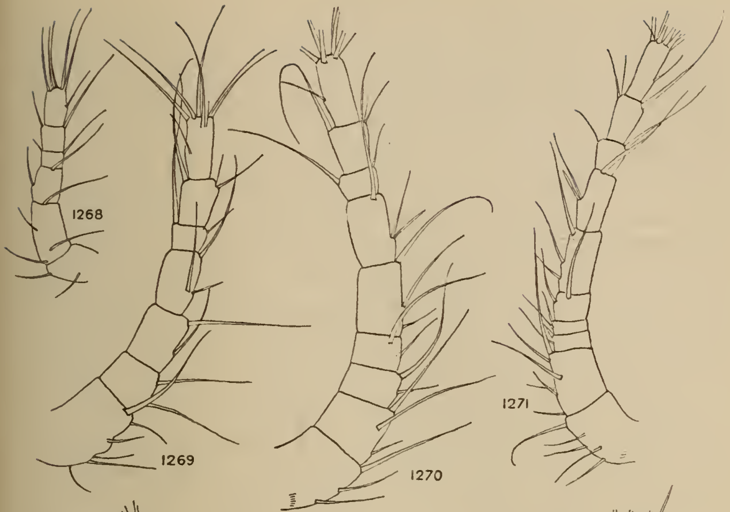
It is not necessary to follow the development of the appendages in detail, except that of the antennule, which is dealt with below. The mouth-parts attain nearly to adult form in copepodid I, but the antenna and mandible retain vestiges of the exopod (Figs. 1266, 1267).

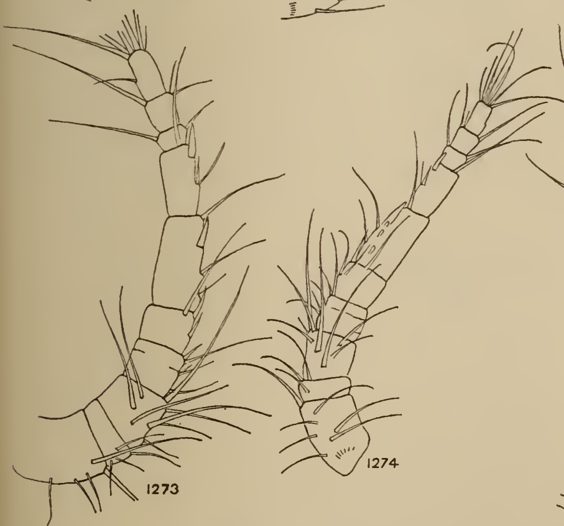
The sexes are distinguishable in stage IV by small differences in the antennule. In *C. strenuus*, for example, it is of 9 segments (seg. 3 usually not divided), and segs. 5 and 6 are stronger than in the female.

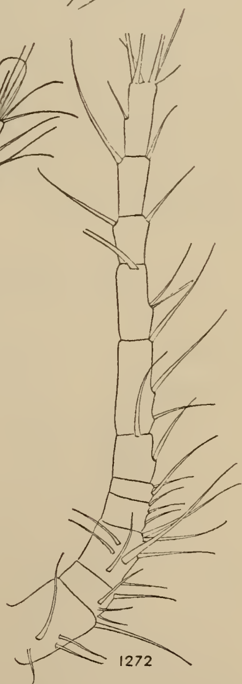
Development of the Antennule.

(Figs. 1268–1283.)

The first copepodid stage has, as a rule, 6 segments in the antennule, but may rarely have 5 or 7. In *C. affinis* and *C. phaleratus* alone it has 4. With successive moults the number increases, and Claus and others have







FIGS. 1268–1274.—ANTENNULE.

FIG. 1268.—Copepodid I, *Cyclops strenuus abyssorum.*
FIG. 1269.—Copepodid II, *C. s. abyssorum.*
FIG. 1270.—Copepodid III, *C. s. abyssorum.*
FIG. 1271.—Copepodid IV, *C. s. abyssorum.*
FIG. 1272.—Copepodid V, female, *C. s. abyssorum.*
FIG. 1273.—Copepodid V, male, *C. s. abyssorum.*
FIG. 1274.—Copepodid V, male, *C. vernalis.*

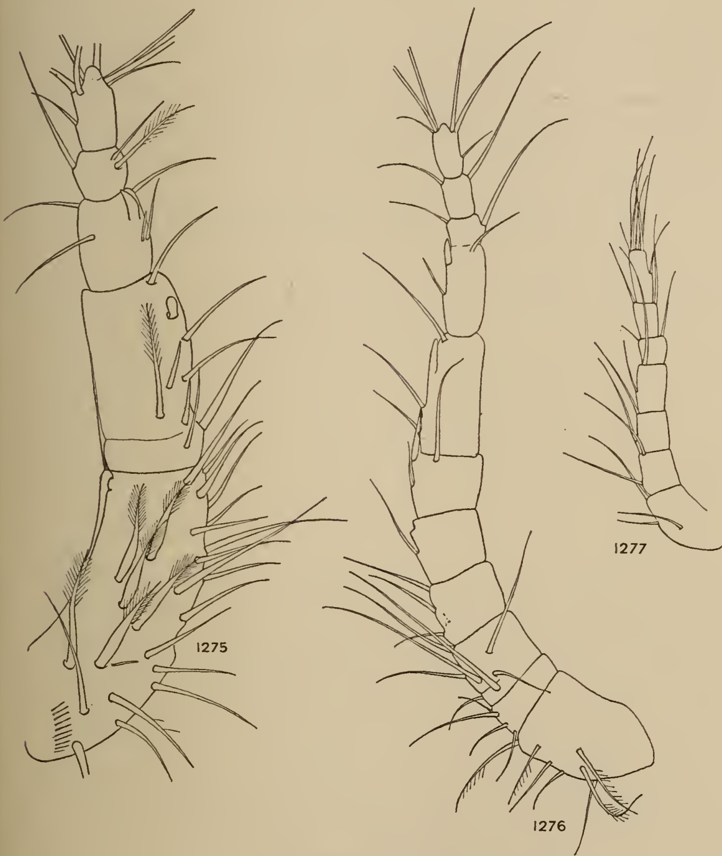
attempted to follow the history of the division of the segments. This is, however, no easy matter, since the number of setæ increases with age, and affords no sure basis for determining which segment has divided. The following sequence of divisions in the normal 17-segmented antennule was first established by Claus, and has been confirmed by Manfredi and Gelmini. I have myself followed it in *C. strenuus*, and believe it to be correct. Oberg (1906) has suggested a possible derivation of the copepodid segments from those of the nauplius, but his scheme, except for the fate of seg. 3 of the nauplius, seems to be untenable. In any case it is a matter of pure speculation, and, in the table, I have divided the antennule into three regions corresponding to the three segments of the nauplius on the assumption that seg. 3 only divides at the last moult. It is certainly the case, in *Cyclops* as in the Calanoida, that the distal segments become separated first, and it seems reasonable to suppose that seg. 3 here, as in Calanoida, gives rise to the whole of the distal part of the prehensile antennule, which corresponds, in *Cyclops*, to segs. 12–17 of the female.

Normal Development of the Antennule.

Nauplius . .	1				2							3					
Copepodid I . .	1				2							3			4	5	6
,, II . .	1				2			3				4			5	6	7
,, III . .	1	2			3		4	5				6			7	8	9
,, IV . .	1	2			3	4	5	6				7			8	9	10
,, V . .	1	2	3		4	5	6	7				8			9	10	11
Adult . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

According to Claus, whose result is confirmed by Manfredi, the antennule of *Eucyclops* does not develop in quite the same way as in other subgenera. There is a difference in the actual numbers of segments in the

different stages, and the fate of the segments in the 7-segmented stage is not exactly the same. As the end-result the part of the 17-segmented antennule



FIGS. 1275–1277.—ANTENNULE.

FIG. 1275.—Copepodid V, male, *C. phaleratus*.
FIG. 1276.—Copepodid V, male, *C. viridis*.
FIG. 1277.—Copepodid II, *C. prasinus*.

corresponding to seg. 7 of *Eucyclops* is derived from seg. 2 of the 7-segmented stage, whereas it is included in seg. 3 in the latter. This is not the case in *C. prasinus*, so that the difference, small as it is, is confined to *Eucyclops*.

C. agilis (= C. serrulatus).

I . . .	1				2				3	4	5	6
II . . .	1				2				3	4	5	6
III . . .	1				2		3		4	5	6	7
IV . . .	1	2			3		4		5	6	7	8
V . . .	1	2	3		4	5	6		7	8	9	10
Adult ♀ . .	1	2	3	4	5	6	7	8	9	10	11	12

C. prasinus (from Manfredi, 1923).

I . . .	1				2				3	4	5	6
II . . .	1				2			3	4	5	6	7
III . . .	1				2		3	4	5	6	7	8
IV . . .	1	2			3		4	5	6	7	8	9
V . . .	1	2	3		4	5	6	7	8	9	10	11
Adult ♀ .	1	2	3	4	5	6	7	8	9	10	11	12

The reduced number of segments in the antennule of some species may be accounted for as the persistence of a larval character in the adult. In the normal course of development the last copepodid has 11 segments and this number is rather commonly found in the adult, *e.g.* in *Microcyclops*; but there are very rarely less among the Bifida. In the group of Trifida here named the Oligarthra the adult number of segments is always 12 or less, and it is suggested by Claus that those with fewer segments are derivable from the *serrulatus*-form of antennule, thus :

C. serrulatus .	1	2	3	4	5	6	7	8	9	10	11	12
C. affinis . .	1	2	3	4	5	6	7	8	9		10	11
C. phaleratus .	1	2	3		4	5	6		7	8	9	10
C. fimbriatus .	1	2			3		4		5	6	7	8

The development of the antennule in these forms is only completely known in *C. phaleratus* (Lucks, 1929), but it is known that the first copepodid in it and in *C. affinis* has only 4 segments in the antennule. In *C. fimbriatus* stage IV is remarkable as having only 6 segments in the antennule, of which seg. 4 represents segs. 5 and 6 of the adult. That is to say, the segment bearing the æsthete is not separated from the following segment, exactly as in the adult of *C. affinis*. It is clear, therefore, that there remains no ground for retaining the latter in a separate genus (see p. 134).

Development of the Antennule in C. phaleratus (*from Lucks*, 1929).

Stage I . .	1						2		3	4
,, II . .	1						2		3	4
,, III . .	1					2	3		4	5
,, IV . .	1					2	3		4	5
,, V . .	1			2		3	4		5	6
Adult . .	1	2	3	4	5	6	7	8	9	10

Development of the Antennule in C. fimbriatus. (Figs. 1278–1283).

Stage I . .	1			2	3		4	5
,, II . .	1			2	3		4	5
,, III . .	1		2	3	4		5	6
,, IV . .	1		2	3	4		5	6
,, V . .	1		2	3	4	5	6	7
Adult . .	1	2	3	4	5	6	7	8

Development of the Antennule in the Male.

Up to stage V it is easy to see that the antennular segments correspond exactly in male and female, but some of the features which distinguish the male antennule

are present. In stage V, segs. 4 and 5 of the male are not completely separated, so that the antennule appears to be of only 10 segments instead of 11, as in the female.

FIGS. 1278–1283.—DEVELOPMENT OF ANTENNULE, *C. fimbriatus.*

FIG. 1278.—Copepodid I.
FIG. 1279.—Copepodid II.
FIG. 1280.—Copepodid III.
FIG. 1281.—Copepodid IV.
FIG. 1282.—Copepodid V, female.
FIG. 1283.—Copepodid V, male.

According to Manfredi it is segs. 2 and 3 which are united, but of this I see no evidence. Seg. 8 bears a seta, 2 stout spines and an æsthete, whereas in the female there are 2 setæ and an æsthete ; while on seg. 7

there is also a spine which is not represented in the female. As to the further fate of these segments there is some difficulty. Mrázek and Claus agree in giving the following scheme of comparison between the two sexes.

♀	1	2	3	4	5	6	7	8	9	10 11	12 13 14	15 16	17
♂	1	2	3	4 5 6	7 8	9	10 11	12	13	14	15	16	17

A number of attempts have been made to homologize the antennule of *Cyclops*, and other forms with reduced number of segments, to that of the Calanoida with 21 or 25. Giesbrecht (1892) appears to have been the first to do this, but he has been followed by Mrázek, Claus and Oberg. Mrázek and Claus assumed a 21-segmented antennule as the stem-form for *Cyclops*, but Giesbrecht (1899) carried the comparison to the more primitive 25-segmented form, and applied it to the Cyclopinidæ and Asterocheridæ also. The following table is extracted from Giesbrecht (1899, p. 131, and 1900, p. 42). The remarkable fact that 17 segments are always traceable in the male antennule of *Cyclops*, even when that of the female has fewer, seems to hold good also for *Euryte* and the Cyclopinidæ. The available evidence is not sufficient for a positive statement, but I am not aware of any exceptions. This may perhaps indicate that antennules of more segments than 17 in the Cyclopinidæ may have arisen by a secondary multiplication of joints.

The exact resemblance of the prehensile antennule of *Cyclops* to that of the Calanoida makes it reasonably certain that the hinge joint lies between homologous segments, so that it is possible to assume that seg. 18 in Calanoida corresponds to seg. 14 in *Cyclops*. A second point which Giesbrecht regards as fixed is that corresponding to seg. 12 in Calanoida, which always bears a spine. In *Cyclops* a similar spine is borne, in

Calanoida	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Euryte ♀	1			2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Cyclopina littoralis ♀	1	2		3				4	5	6			7	8	9	10	11	12	13	14	15	16	17	18	
,, *elegans* ♀	1	2		3				4	5	6	7	8	9			10	11	12	13	14	15	16	17	18	
Cyclops ♀	1			2		3	4			5		6	7		8	9	10	11	12	13	14	15	16	17	

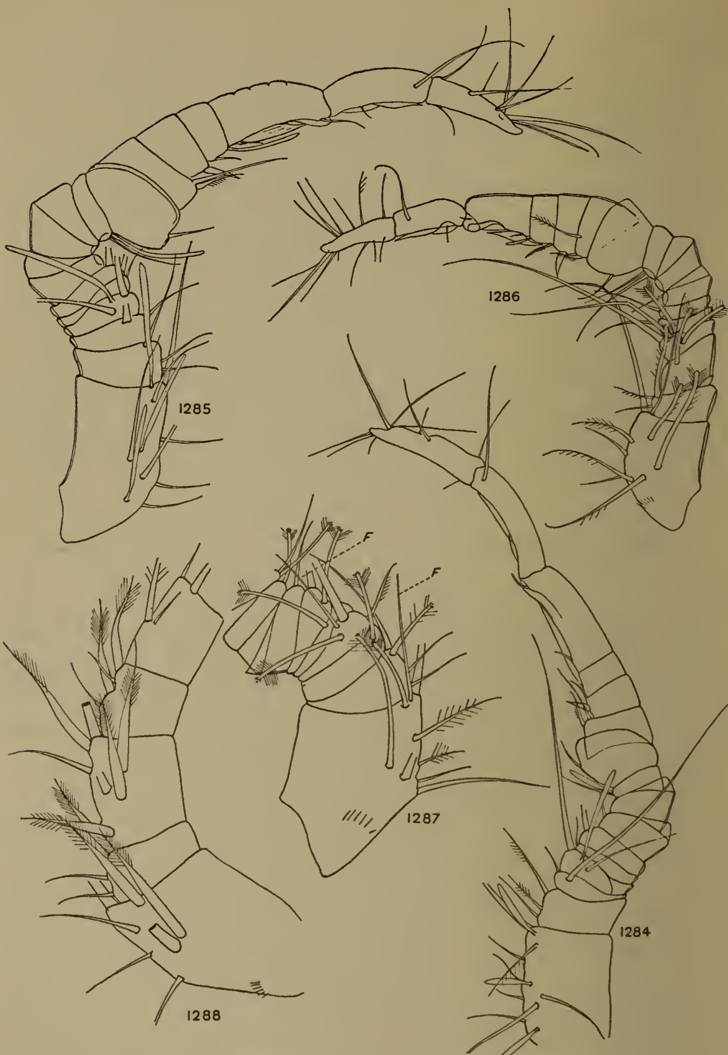
the female, on seg. 6, which is clearly a single segment. Where a segment is long, or bears more than 2 setæ, it is assumed to be composite, and it is reasonable to accept the correspondence shown by Giesbrecht. At the same time, having regard to the probable fusion of segments even in the most primitive antennules known (see Vol. I, p. 40), and to the general departure from the arrangement of setæ which we suppose to be primitive, it is hardly more than an attractive speculation to prepare tables of this kind. They do, it is true, lead to the conviction that all forms of antennule have a common ground plan, and that particular æsthetes or setæ are remarkably persistent through large groups; but it is hardly possible to make deductions of systematic value from these assumed homologies.

The Prehensile Antennule in the Adult.

(Figs. 1284–1290.)

The great modification of the prehensile antennule, particularly in the proximal part, makes it difficult to make out the exact structure, and the difficulty is much increased by the very different appearance of the same segments in different states of contraction.

The limb is divisible into three regions, proximal, middle, and distal, consisting of segs. 1–9, 10–14, and 15–17 respectively, and each part is flexible upon the next. All the segments from 2 to 11 are freely movable, but the main point of flexure is between segs. 7 and 9. The distal portion of these segments is membranous, and this membranous part can be invaginated into the proximal part in the position of complete extension. The distal section flexes as a whole upon section 2 by an actual hinge between segs. 14 and 15, or itself flexes on a hinge between the last 2 segments. There are a number of æsthetes, which are constant in position. In all the Bifida these æsthetes are more or less club-shaped and have been called " sense-clubs " (Sinnes-Kolben, Claus). These clubs may be quite short (*C. strenuus*) or very



Figs. 1284–1288.—Prehensile Antennule.

Fig. 1284.—*C. leuckarti.*
Fig. 1285.—*C. venustus.*
Fig. 1286.—*C. agilis.*
Fig. 1287.—*C. albidus*, segs. 1–9.
Fig. 1288.—*C. albidus*, copepodid V, segs. 1–5.

long (*e. g. C. venustus*). In *C. varicans* they attain to extreme length (Fig. 1754). In all cases they are constricted at the base and smooth throughout. There are 3 on seg. 1, and one each on segs. 4, 9, 13 and 15. Mrázek states that in *C. oithonoides* there is only one on seg. 1, and none on segs. 13 and 16, but I am not aware of any other exception.*

The sense-clubs are not represented in the female, unless that of seg. 15 in the male is homologous with that of seg. 12 in the female, and they appear at the moult to the adult form. They are not modified setæ, since the normal number of setæ is present on seg. 1, for example, in addition to the clubs.

In the Trifida the sense-clubs are not represented on the proximal part. In place of them are found very long cylindrical æsthetes, or sense-cylinders, which are either delicately feathered throughout, or have a circlet of long hairs at the end (Figs. 1286, 1287). These are also present in definite numbers, as shown in the table ; but, as Claus discovered, they represent modified setæ. In *C. albidus*, for example, the normal number of setæ is present on seg. 1 in the last copepodid stage, but 2 of these are distinguished from the rest by their lanceolate shape and delicate feathering (Fig. 1288). In the adult there are 6 setæ only, with 2 cylinders. There is, however, in addition, a long hyaline sensory seta at the end of the segment which is probably homologous with the terminal club of the Bifida. A similar sense-seta is also present on seg. 4, in addition to the cylinder. On segs. 13 and 15 the same form of æsthete is found in Trifida as in Bifida ; but the relation of the æsthetes on seg. 9 is not quite clear. Whereas in *Macrocyclops* there is a well-developed cylinder and a seta, in *C. serrulatus* there is a sensory seta in place of a cylinder and in the Bifida a normal club. It seems as if, in this case, the three forms of æsthete are homologous structures. The difference between the two groups therefore consists, not in the absence of clubs from the

* I have not been able to see a club on seg. 15 in *C. leuckarti*.

Trifida, but in their partial absence, and in the presence of the cylinders. These cylinders are found in all the Trifida, except *Tropocyclops*, in which the setæ are apparently not modified ; but they are more numerous in *Macrocyclops* than in the others.

DISTRIBUTION OF THE ÆSTHETES ON THE MALE ANTENNULE.

Segments.	*Cyclops.*	*Eucyclops.*	*Macrocyclops.*
1	A.A.A	CC.F	CC.F
2	. .	C	C
3	. .	C	C
4	A	C.F	C.F
5	. .	C	C
6	. .	. .	C
7	. .	. .	. .
8	. .	. .	C
9	A	F	C.F
10	. .	. .	. .
11	. .	. .	. .
12	. .	. .	. .
13	A	A	A
14	. .	. .	. .
15	A	A	A
16	. .	. .	. .
17	F	F	F

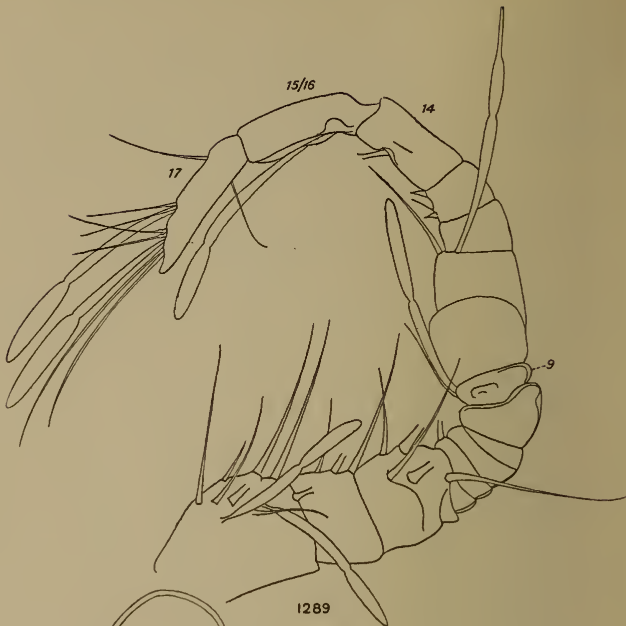
A = sense-clubs ; C = sense-cylinders ; F = sense-hairs.

It would be interesting to compare the distribution of the æsthetes in the Cyclopoida as a whole, but the material for such comparison is not adequate. I do not find in literature any useful information about the æsthetes in *Cyclopina*, and have been unable to obtain material myself ; of *Euryte* a good figure of the antennule is given by Giesbrecht (1900), and I have also seen a

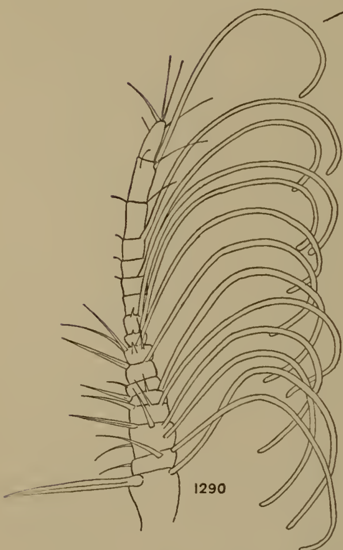
Comparison of the Antennule in Diaptomus *and* Cyclops.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.
Diaptomus ♀ setæ .	1	3	1	1	1	1	1	1	2	1	2	1	2	2	2	2	2	2	2	1	1	1+1	1+1	1+1	5
Æsthetes . . .	A.	A.	A.		A.		A.	SP.	A.			A. SP.		A.		A.			A.						A.
Cyclops ♀ segs. . .		1		2		3		4		5		6	7		8	9	10	11	12	13	14	15	16	17	
Setæ . . .		8		3		2		6		3		1	2		1	1	0	1	1	0	1	1+1	1+1	7+1	
Æsthetes, etc. . .								SP.											A.				A.	A.	
Cyclops ♂ . . .		1		2		3	4	5	6	7	8	9	10	11	12	13	14			15		16		17	
Æsthetes . . .		3A.					A.					A.				A.				A.				A.	

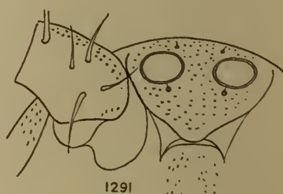
A. = Æsthete. SP. = Spine.



1289



1290



1291

FIGS. 1289–1290.—ANTENNULE OF MALE.

FIG. 1289.—*Euryte minor.*
FIG. 1290.—*Dermatomyzon* sp.

FIG. 1291.—Frontal discs in copepodid V, *Cyclops strenuus.*

single specimen of *E. minor* myself (Fig. 1289). It is by no means easy to determine with certainty the exact number and position of all these transparent bodies, but in *E. minor* there appear to be 9 or 10 as follows :

Segs.	1	4	9	11	13	15	16
Æsthetes	3	1	?	1	?	1	2

These æsthetes are of immense size, more or less parallel-sided at first, but widening out distally. They seem to be homologous with the sense-clubs of *Cyclops*, rather than with the cylinders of *Macrocyclops* ; *i. e.* they are not modified setæ. In *Halicyclops* (Fig. 1226) they are much shorter than in *Euryte*, but there are more of them than in *Cyclops*. In many of the semiparasitic genera the æsthetes are extremely long, and may be numerous. In *Pteropontius* there are 14 (Giesbrecht), and I find the same number in a species of *Dermatomyzon* from Plymouth (Fig. 1290). It seems probable that each segment primitively bore one æsthete, and the large number retained by some *Ascomyzontidæ* suggests a very early origin from a pre-Cyclopinid ancestor.

Frontal Discs.

(Fig. 1291.)

The name " corneal lenses " was first given by Claus (1863, p. 45) to a pair of circular discs which may be seen in *Cyclops* above the rostrum. They were seen also by Hartog (1884, p. 34) and Richard (1891, p. 208), both of whom adopted Claus's view that these discs were lens-like bodies associated with the eye.

Gicklhorn (1930b) has made a special study of these discs, and finds that they stain strongly with the same stains as affect the æsthetes of the antennule. Furthermore, they are areas of specially thin cuticle, and consequently by no means lens-like. He was able to show that they are innervated by special nerves direct from the brain, and he suggests that they are sensory areas, actually of the same origin as the æsthetes. His

theory is that the æsthetes are outpushings of a membranous integument, and that the discs may arise by union and flattening of such protuberances.

These "frontal discs" are very difficult to see, especially in the living animal, but they have been seen in several species, *e. g. C. viridis* by Mr. Scourfield, and are probably present in most, if not all. I find it difficult to believe that they represent modified æsthetes, but that they are sensory, and not concerned with vision, seems well established. Probably they are homologous with the cuticular discs found in some Harpacticids (Vol. II, p. 22).

Legs of Cyclops. Setæ and Spines.

The arrangement of spines and setæ on the legs often affords useful systematic criteria. While it is true that in certain species (*C. vernalis*) there is some individual variation in the number of spines on exopod 3, as a general rule there is such constancy that the spine formula may be accepted as part of the diagnosis of a species. The possible alternatives are either 2.3.3.3, 3.4.3.3, or 3.4.4.4, apart from abnormal individuals such as are met with rather commonly in *C. furcifer*. The difference in formula does not characterize groups of species, but may differ in species closely allied, such as *C. strenuus* and *C. vicinus*. When the legs are 2-segmented, seg. 2 represents segs. 2 and 3, so that the formula may be stated by deducting the spine of seg. 2. In such cases the formula is 2.3.3.2 (*C. varicans*, *C. gracilis*).

There is also constancy in the number of setæ on exopod 3, the number being either 4 or 5, when the leg is 3-segmented. In all Trifida, in the species of the *strenuus* group, and in *C. venustus* and *C. capillatus* there are 5 setæ. In all the rest there are 4. This is true also for species with legs 2-segmented if one seta is deducted as belonging to seg. 2.

The constancy in the arrangement of setæ is subject

to some remarkable exceptions. In all species except *C. leuckarti*, *C. minutus* and some forms of *C. prasinus* there is an inner seta on the basis of leg 1 ; in all species except *C. sensitivus*, *C. unisetiger* and *C. demetiensis*, exopod 1 of legs 1–3 has an inner seta ; in *C. varicans*, *C. rubellus*, *C. bicolor* and *C. gracilis* this seta is present on legs 1–3 but absent from leg 4 ; endopod 2 of leg 3 has 2 inner setæ, but only 1 in the *languidus* group and in *C. sensitivus*.

It is clear that the arrangement of these spines and setæ is of systematic importance ; but it does not help much in grouping the species in subgenera.

Tables of Measurements.

While the recognition of constant differences between populations, and the definition of varieties and subspecies where such differences are established, is perfectly legitimate, and may lead eventually to the elucidation of bionomical problems, some caution is necessary. An overlap of characters between the extremes which are to be designated as subspecies does not necessarily show that such separation is not desirable since, in the nature of things, transition must or may precede separation. On the other hand, where such transitional forms are so common that it is often impossible to refer an individual to its correct category, and where, moreover, the two extreme forms are to be found associated together without any apparent ecological preferences, the separation becomes not only unpractical, but also loses scientific value. In any case, where "critical" species or subspecies are recognized it is desirable that they should rest as far as possible upon some statistical basis. This is most difficult for those species which are rare both in occurrence and in individuals, such as the forms of *C. languidus* ; but it is relatively easy for *C. strenuus* and *C. serrulatus*, where material is easily collected. At the same time measurements of many individuals is a tedious business, and few can give the time to deal

with really adequate numbers. Further, not all are able to understand and to appreciate the value of figures for "probable error" and correlation. I have, for these reasons, endeavoured to give in most cases measurements of this kind; but it has not been possible as a rule to do more than measure single individuals of each population, and the tables are offered with full recognition of their defects. It must be pointed out that measurement of these creatures presents peculiar difficulties. In the first place, absolute accuracy in measuring a seta is almost impossible. Setæ are commonly so fine towards the end that it is not always possible to be sure that the end has been correctly seen, and it may have been broken or worn away. Further, in order that comparison should be possible, all measurements must be reduced to a common standard. The length of any part should evidently be compared with the length of the whole body, and this has been adopted as the standard; but it is unfortunate that Copepods are subject to considerable contraction when preserved. Measurements of living animals cannot therefore be compared with those of preserved material. As the latter must be generally dealt with, it is necessary to use it exclusively; but it must be admitted that even so the comparison is not perfect, since contraction may not be uniform. I have prepared tables with the same measurements reduced to comparison with other parts not subject to contraction and accurately measurable; but they have been abandoned in favour of body-length as a standard, partly because that standard has been already used by others (*e. g.* Kozminski), and partly because they were less satisfactory for other reasons.

In these tables the measurements of width of body, length of rami and of furcal setæ are converted to compare with total length of body (including rami) taken as 1000. The terminal spines of the endopod of leg 4 are compared with each other, and with the length of endopod 3, the length of the latter and of the shorter of the two spines being taken as 100. Mr. Lowndes

(1932c) has adopted a similar form of table. In all cases the apical furcal setæ are counted from outer to inner, the innermost being seta 4.

SECTION I. TRIFIDA.

This group corresponds exactly to Kiefer's Eucyclopinæ, but, instead of regarding these subgenera as forming one related group, I prefer to draw a distinction between *Macrocyclops* and the rest, since they appear to represent two distinct lines of evolution. The main reason for doing so is the structure of the nauplius. So far back as 1882 Frič recognized that the larvæ of *C. serrulatus*, *C. fimbriatus* and *C. phaleratus* have certain characters in common, and Amelina (1927) has shown that the nauplii fall into two series according to the form of the antenna. The exopod of the antenna in *Macrocyclops* and all Bifida appears to have 5 segments, but in some cases 7 can be detected. In all cases the last 4 segments are of about equal size, though, in *Macrocyclops*, there is a tendency to compression of the middle ones. In the group which includes *Eucyclops*, *Tropocyclops*, *Paracyclops* and *Ectocyclops* the exopod is rather small, and the middle segments are so small and compressed that it is difficult to make them out at all. In all cases the last segment is very long and slender. A further point of difference between the two groups relates to the antennule in the adult, which never exceeds 12 segments in the Oligarthra. According to Claus the development of these segments does not follow the same course in the Copepodid of *Eucyclops* as it does in *Cyclops* with 17 segments (see p. 48).

The position of *Tropocyclops* is a little doubtful. It has been generally agreed that it is most closely allied to *Eucyclops*, reliance being placed on the structure of leg 5 and antennule. Graeter alone has pointed out its remarkable similarity to *C. fuscus* in form, habit and colour, and, in his phylogenetic table, he assumed a derivation of it from the same stem as *C. fuscus*. With

this view I have much sympathy. In the structure of the furcal rami and the general form of the nauplius it differs so markedly from *Eucyclops* that association with *Macrocyclops* seems necessary. The nauplius also has the long seta on the mandible basis which is so conspicuous in *Macrocyclops*. On the other hand, the exopod of the nauplius antenna is exactly of the *Eucyclops* form, and the ventral hairs are not in transverse rows. It is, in fact, a transitional form, but best regarded as associated with *Eucyclops*.

The whole group is characterized by having 3 apical setæ* or spines on leg 5 ; but it is doubtful if this fact has the importance hitherto attached to it. It is at least arguable that the outer seta of *Eucyclops*, for example, represents the seta of the basis in the 2-segmented leg of the 'Bifida.' This is certainly the case in the vestigial leg 6, and leg 5 of *C. phaleratus* so closely resembles leg 6 that it is difficult to believe that the setæ are not homologous. In *Macrocyclops ater* leg 5 seems to have lost the basal segment, leaving a single segment with a short spine and 2 setæ, resembling that of *C. serrulatus*, and it may be argued that therefore we must regard the single segment in *Eucyclops* as the equivalent of seg. 2 in normal *Macrocyclops*. On the other hand, in certain species of *Microcyclops* leg 5 is reduced to 3 setæ springing from the margin of the somite, of which the outer one is supposed to correspond to the seta of seg. 1, and the other two to those of seg. 2. The result is a remarkable resemblance to the leg of *Ectocyclops*. It is hardly possible to arrive at any positive solution of such a dilemma. Reduction of limbs has certainly occurred independently in different lines of evolution, and it is not very safe to base a primary division upon one seta more or less in a limb, especially when the homology of the setæ in question is so obscure. In maintaining Graeter's groups Trifida and Bifida, I rely entirely on the fact that it is in the former group

* With the exception of *Thaumasiocyclops*, Kiefer (1930J), founded for *T. insulanus* from a spring in Bali. This is said to be related to *Paracyclops*.

alone that certain setæ of the male antennule are modified into æsthetes which Claus termed "Spürcylindern." These are more numerous in *Macrocyclops* than in the remaining genera of the group. In all other *Cyclops* the male antennule has its normal complement of setæ, with club-shaped æsthetes in addition (see p. 57).

Subgenus **MACROCYCLOPS**, Claus.

1893. Claus, Anz. Ak. Wien, no. 9, p. 82.
1897. *Homocyclops*, Forbes, Bull. Ill. Lab. V, p. 49.
1914. *Pachycyclops*, Sars, Crust. Norway, VI, p. 64.
1929. *Macrocyclops*, Kiefer, Tierreich, Lief. LIII, p. 26.

Large, robust species ; furcal rami short, the outer and inner apical setæ long and feathered ; antennule of 17 segments, with hyaline membrane on segs. 15–17 ; rami of legs 1–4 3-segmented ; leg 5 2-segmented (except *C. ater*, Herrick), seg. 2 with 2 long spines and a median seta. Nauplius with transverse rows of hairs on ventral side.

Type.—*C. fuscus*, Jurine.

Subgenus Macrocyclops. Key to British Species.

1. Hyaline membrane of antennule strongly toothed . *C. fuscus*.
   This membrane smooth or minutely serrated . . . 2.
2. Inner margin of furcal rami smooth ; distal inner seta of leg 4 end. 3 reduced . . . . . . *C. albidus*.
   Inner margin of rami hairy ; distal inner seta of leg 4 not reduced . . . . *C. distinctus*.

Cyclops fuscus, Jurine.

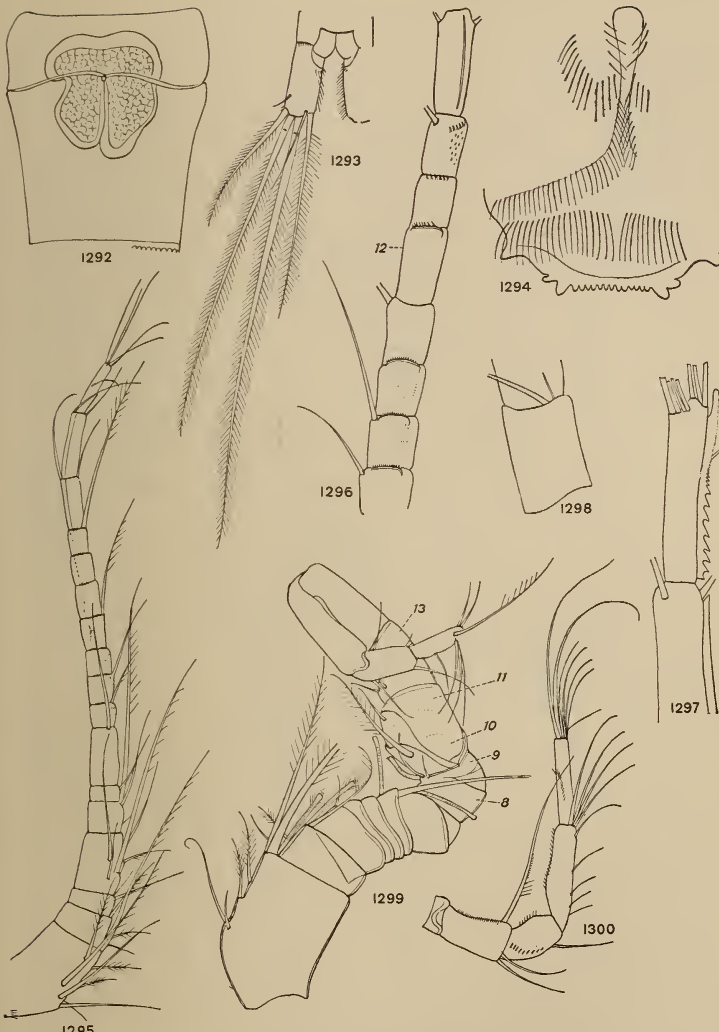
(Figs. 1292–1313.)

1820. *Monoculus quadricornis fuscus*, Jurine, Hist. Monoc. p. 47, fig.
1838. *Cyclops signatus*, Koch, Deutschl. Crust. Heft. 21, No. 8.
1857. *C. coronatus*, Claus, Arch. Naturg. XXIII, 1, p. 29, figs.
1863. ,, Lubbock, Trans. Linn. Soc. XXIV, p. 199.
1880. *C. signatus*, Brady, Mon. Brit. Cop. I, p. 100, figs.
1887. *C. palustris*, Sowinsky, Mém. Soc. Kiew. VIII, p. 52, figs.
1892. *C. signatus* (part), Brady, Trans. N. H. Soc. Northd. XI, p. 72.
1892. *C. fuscus*, Schmeil, Bibl. Zool. XI, p. 123, figs.
1893. *Macrocyclops coronatus*, Claus, Arb. Zool. Inst. Wien. X, p. 347, figs.
1910. *Cyclops fuscus*, Marsh, Trans. Wisc. Acad. XVI, p. 1090, figs.
1914. *Pachycyclops signatus*, Sars, Crust. Norway, VI, p. 65, figs.
1929. *Macrocyclops fuscus*, Kiefer, Tierreich Lief. LIII, p. 27, figs.

Female.—Length 2·0–2·5 mm.

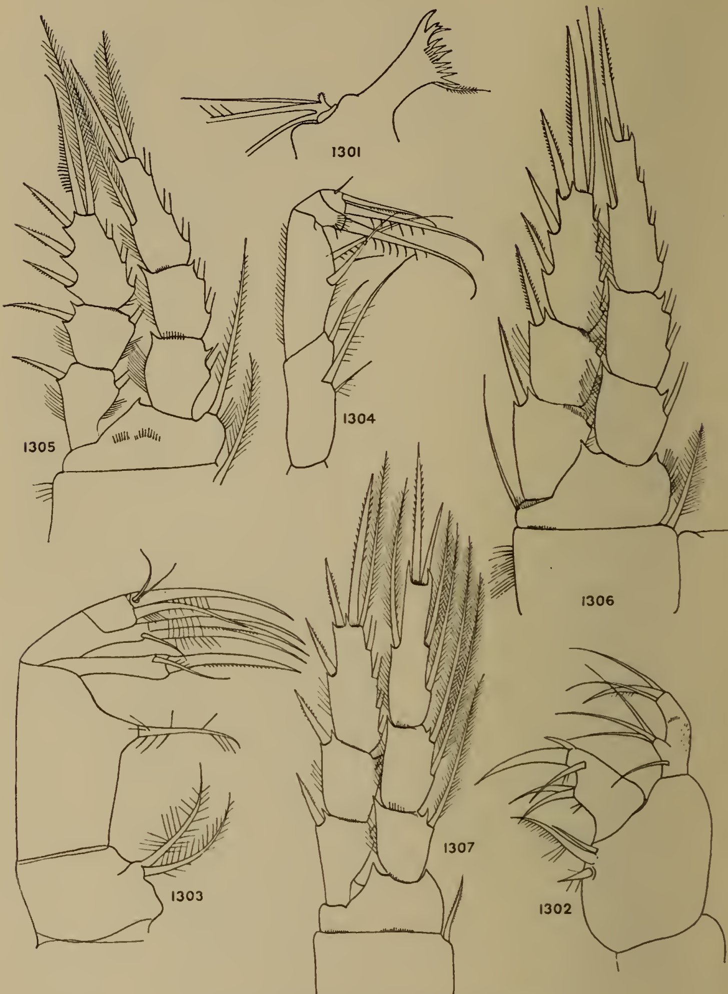
Thorax more or less ovate, greatest width in mandibular region, tapering behind; th. som. 5 not wider than gen. somite, with small spinules on outer margin ventrally. Genital somite longer than wide (89 : 79); receptaculum large, brick-red in colour, the posterior part cleft into two apposed sacs. Furcal rami short and stout, about twice as long as wide, inner margin hairy; lateral seta very small and inserted near end; outer apical seta about two-thirds as long as inner, the latter about 3 times as long as ramus.

Antennule of 17 segments, reaching back to end of thorax; seg. 12 with an exceedingly small æsthete; segs. 8–11 and 12–14 with transverse distal row of denticles, stronger on segs. 12–14; seg. 16 lacking the usual sensory hair. Segs. 15–17 with broad hyaline membrane; in seg. 17 this membrane projects beyond end of segment, and is deeply serrated in its proximal half. Antenna very long and slender, the last 2 segments about equal in length, and very much longer than seg. 2. Mandible with 3 setæ on vestigial palp, the inner seta as long as the distance from palp to end of blade. Maxilla with seg. 2 unusually long, about twice as long as wide. Maxillipede very slender, seg. 2 longer than seg. 1. Legs with spine formula 3.4.4.3. Leg. 1, basis with inner seta reaching beyond endopod 2; outer apical seta of exopod smooth on inner side, but armed with stout bristles on outer margin. Coxa of all legs with fringe of hairs. In leg 1 exopod 1 and 2 have outer fringe of hairs, but seg. 1 is smooth in legs 2–4. Leg. 4, inner coxal seta short and spine-like; endopod 3 long and slender, more than 3 times as long as wide; outer terminal spine longer than inner, and about 90% of length of seg. 3; distal inner seta of endopod 3 well developed. Uniting lamella of leg 4 with convex margin, armed with a fringe of strong spines; posterior surface with 2 transverse rows of spinules, the distal row long and widely spaced, the proximal small and close together. Leg 5, seg. 1 much



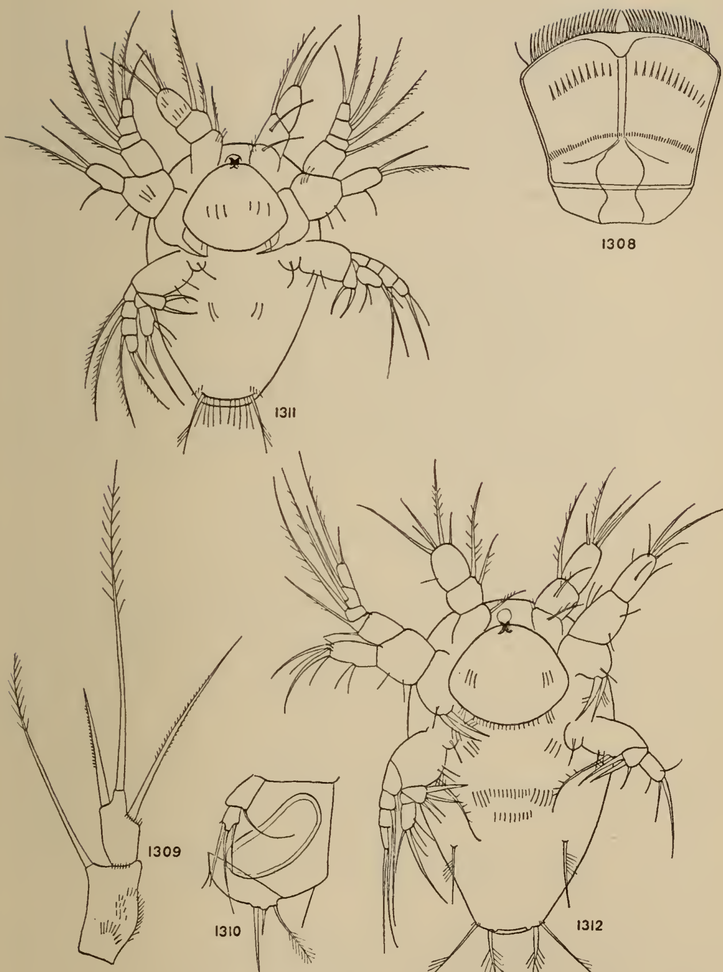
FIGS. 1292–1300.—*Cyclops fuscus.*

FIG. 1292.—Genital somite and receptaculum.
FIG. 1293.—Furcal rami.
FIG. 1294.—Upper lip.
FIG. 1295.—Antennule, female.
FIG. 1296.—Antennule, segs. 8–15.
FIG. 1297.—Antennule, seg. 17.
FIG. 1298.—Antennule, seg. 12.
FIG. 1299.—Antennule, male, dorsal.
FIG. 1300.—Antenna.



FIGS. 1301–1307.—*Cyclops fuscus.*

FIG. 1301.—Mandible.
FIG. 1302.—Maxillule.
FIG. 1303.—Maxilla.
FIG. 1304.—Maxillipede.
FIG. 1305.—Leg 1.
FIG. 1306.—Leg 3.
FIG. 1307.—Leg 4.



FIGS. 1308–1312.—*Cyclops fuscus.*

FIG. 1308.—Leg 4, uniting lamella.
FIG. 1309.—Leg 5.
FIG. 1310.—Legs 5 and 6, male.
FIG. 1311.—Nauplius, stage I.
FIG. 1312.—Nauplius, stage III.

longer than seg. 2, hairy on inner side; seg. 2 bearing a long median terminal seta and an outer and inner spine, the latter much the longer. Egg-sacs dark brown, closely pressed to abdomen.

Colour: Occasionally nearly colourless, but generally richly coloured, and appearing almost black to naked

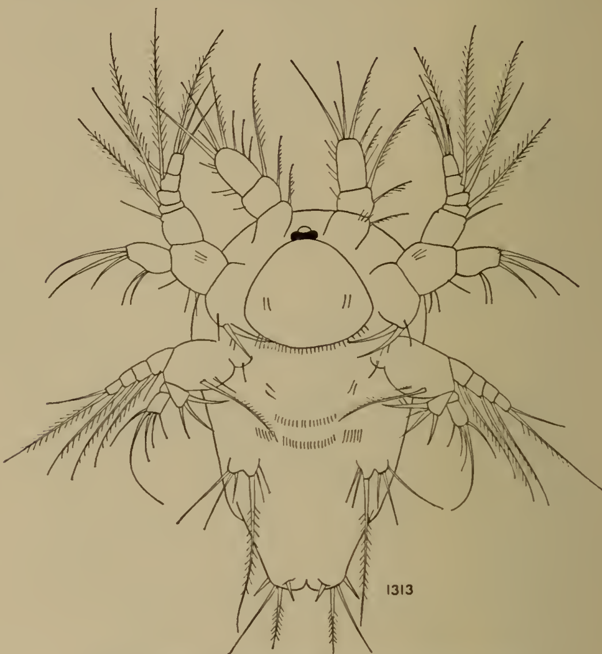


FIG. 1313.—*Cyclops fuscus*, nauplius, stage IV.

eye; rami and abdomen bluish green; thorax dark green, with blue patches; receptaculum brick-red.

Male.—Length 1·19 mm.

Antennule with long parallel-sided æsthetes (sense-cylinders); of these there are 2 on seg. 1 and 1 each on segs. 2, 3, 4, 5, 6, 8, 9. These cylinders have blunt ends, often rather dilated, and there is generally a granular mass at the end which has the appearance of

a secretion. The sides of the cylinders bear very delicate hairs, but these may sometimes be absent or confined to distal end. In addition to the cylinders there are also 3 sensory hairs, corresponding to 3 of the æsthetes of other forms, on segs. 1, 4 and 9. Leg 6 with outer feathered seta and 2 smooth spine-like setæ, of which the outer one is less than half as long as inner.

Distribution in Britain.

Generally distributed throughout the British Isles, but apparently rarer in the north (Scotland) than in the south and east. Scott gives several localities in Scotland, but I have only taken it twice myself (near Lairg, and in Jura). Not uncommon in Ireland.

Distribution Abroad.

Generally distributed over Europe.

North Africa : Algeria (Roy and Gauthier).

Asia : Mongolia (Daday) ; Japan (Kokubo) ; Turkestan (Daday) ; Transcaspia (Walter) ; Sumatra (Daday).

North America : Nebraska (Pearse) ; Pennsylvania (Spaeth) ; Wisconsin, Michigan, Massachusetts, Illinois, Louisiana, etc. (Marsh, Kiefer).

South America : Paraguay (Daday).

Bionomics.

Found only in clear weedy waters. Present throughout the year, but much commoner in summer. Wolf (1905, p. 175) found 3 maxima—in spring, summer and autumn.

Cyclops albidus, Jurine.

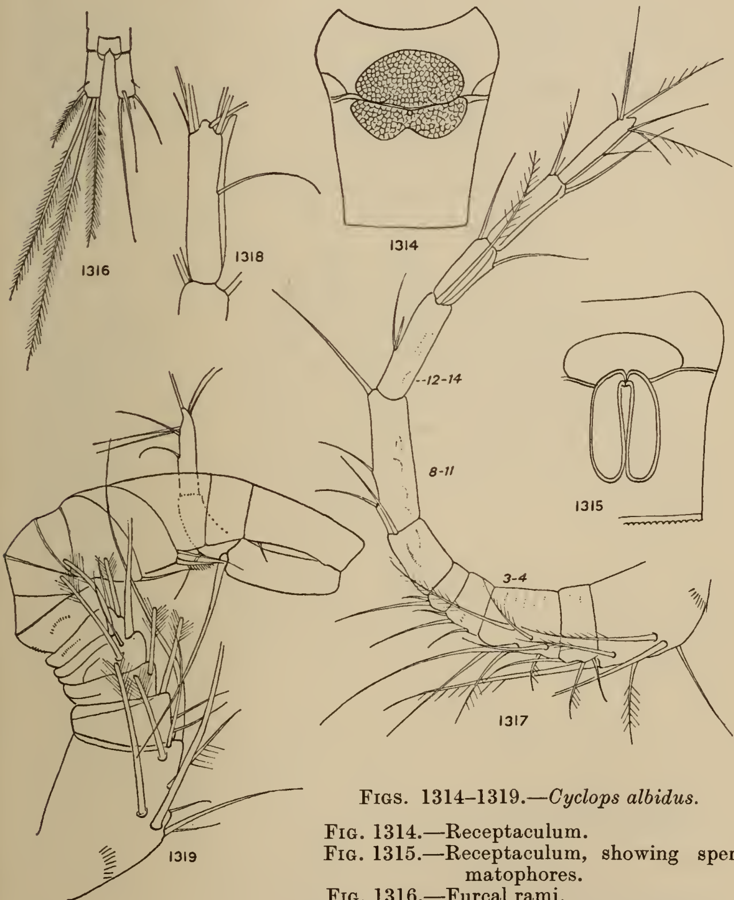
(Figs. 1314–1331.)

1820. *Monoculus quadricornis albidus*, Jurine, Hist. Monoc. p. 44, figs.
1838. *Cyclops annulicornis*, Koch, Deutschl. Crust. Heft. 21, no. 6.
1857. *C. tenuicornis*, Claus, Arch. Naturg. XXIII, 1, p. 31, figs.
1857. *C. pennatus*, Claus, *ibid.*, p. 35, figs.
1863. *C. tenuicornis*, Lubbock, Trans. Linn. Soc. XXIV, p. 202.
1874. *C. clausi*, Poggenpol, Nachr. Ges. Mosk. X, p. 70, figs.
1874. *C. latissimus*, Poggenpol, *ibid.*, p. 71, figs.
1878. *C. tenuicornis*, Brady, Mon. Brit. Cop. I, p. 102, figs.
1891. *C. gyrinus*, S. A. Forbes, Rep. U.S. Fish Comm. for 1887, p. 707, figs.
1892. *C. albidus*, Schmeil, Bibl. Zool. XI, p. 128, figs.
1892. *C. signatus* (part), Brady, Trans. H. N. Soc. Northd. XI, p. 71.
1893. *Macrocyclops tenuicornis*, Claus, Arb. 2, Inst. Wien, X, p. 347, fig.
1909. *Cyclops viridosignatus*, Byrnes, Cold Spring Harb. Mon. p. 23, figs.
1914. *Pachycyclops annulicornis*, Sars, Crust. Norway, V, p. 68, figs.
1929. *Macrocyclops albidus*, Kiefer, Tierreich, Lief. LIII, p. 28.

Female.—Length 1·5–2·5 mm.

Thorax less narrowed behind than in *C. fuscus*, greatest width in mandibular region; th. som. 5 not wider than gen. somite and with transverse rows of spinules laterally; gen. somite longer than wide; receptaculum colourless, with posterior part not produced backwards, concave behind. Hyaline membrane of abdominal somites with shallow indentations. Furcal rami less divergent than in *C. fuscus*, nearly 3 times as long as wide; inner margin without hairs; lateral seta inserted rather on dorsal side, and very near apex. Inner apical seta about twice as long as outer; seta 3 more than half length of body. Antennule of 17 segments, reaching beyond thorax; segs. 8–10 and 12–14 with rows of small denticles, smaller than in *C. fuscus*, and on ventral side only. Æsthete of seg. 12 well developed, as long as seg. 13; æsthete of seg. 16 very small and slender. Segs. 15–17 with broad hyaline membrane; membrane of segs. 15, 16 apparently smooth, but that of 17 generally minutely serrated, at least distally. Antenna not so long or so slender as in *C. fuscus;* seg. 3 very much shorter than seg. 4; lengths of segs. 42, 35, 30, 47. Mandible with 2 very long setæ, and 1 very small seta, not reaching end of

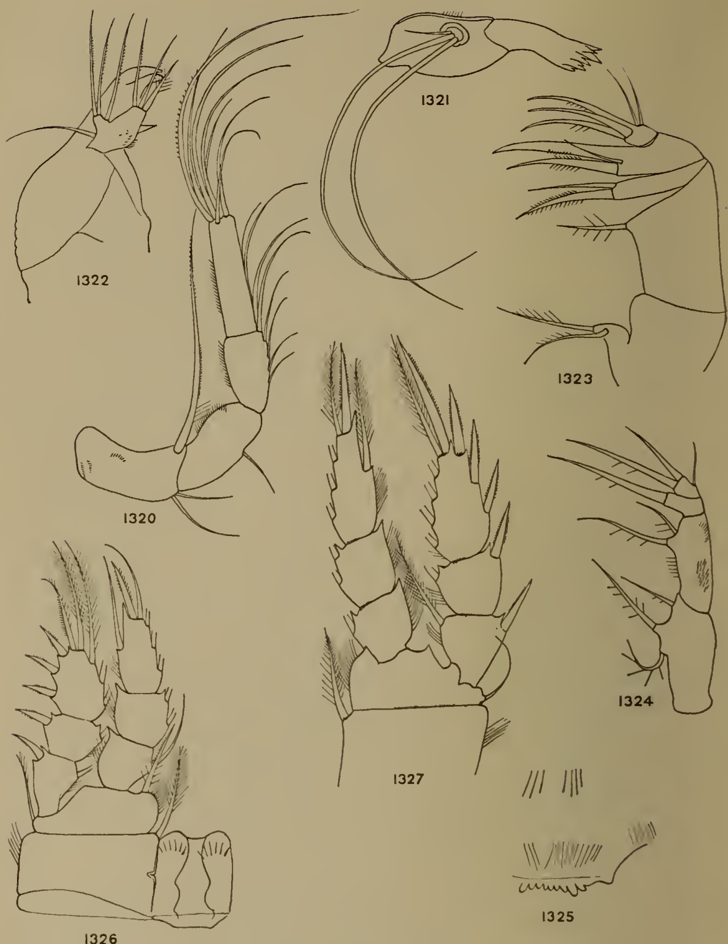
blade; papilla, representing palp, without the process found in *C. fuscus*. Maxillule, maxilla and maxillipede as in *C. fuscus*, but with small differences in lengths of



FIGS. 1314–1319.—*Cyclops albidus*.

FIG. 1314.—Receptaculum.
FIG. 1315.—Receptaculum, showing spermatophores.
FIG. 1316.—Furcal rami.
FIG. 1317.—Antennule, female, stage V.
FIG. 1318.—Antennule, seg. 17.
FIG. 1319.—Antennule, male.

certain setæ and spines (Neubaur, 1913). Swimming-legs as in *C. fuscus*, but with small differences in the uniting lamella of legs 3 and 4. In leg 4 this lamella has the same 3 rows of spinules, but the marginal spines



FIGS. 1320–1327.—*Cyclops albidus.*

FIG. 1320.—Antenna.
FIG. 1321.—Mandible.
FIG. 1322.—Maxillule.
FIG. 1323.—Maxilla.
FIG. 1324.—Maxillipede.
FIG. 1325.—Upper lip.
FIG. 1326.—Leg 1.
FIG. 1327.—Leg 3.

are not so stout, and those of the posterior face are slender and hair-like. Leg 4, endopod 3 less than 3 times as long as wide ; distal inner seta greatly reduced, not plumose ; outer terminal spine smooth, very little shorter than inner. Leg 5 practically identical with that of *C. fuscus.* Egg-sacs large, very divergent.

Colour : Generally greyish, with darker bands across thorax, and with 2 bands on antennules in region of segs. 2 and 3 and 8 and 9. The colour markings correspond closely in both species, and in *C. distinctus* ; but whereas in the latter and in *C. fuscus* they are blue, in *C. albidus* blue is replaced by black (Neubaur).

Male.—Length ·96 mm.

The male differs scarcely at all from that of *C. fuscus* in antennule or leg 6. The spermatophore, however, is much more elongated, and the sperms within it are seen closely packed in the basal part, whereas in *C. fuscus* they are enclosed and hidden by the glandular contents of the sac. The sperms themselves are much larger and more elongated in *C albidus.*

Distribution in Britain.

Generally distributed throughout British Isles, to the far north of Scotland. Very common in Scottish lochs.

Distribution Abroad.

Common throughout Europe.

North Africa : Algeria (Roy and Gauthier, R. G.) ; Egypt (Richard).

Central Africa : Cameroons (Kiefer) ; Lake Nyasa (Sars) ; Abyssinia (A. G. L.).

Asia : Mesopotamia (R. G.) ; Java (Daday) ; Mongolia (Daday).

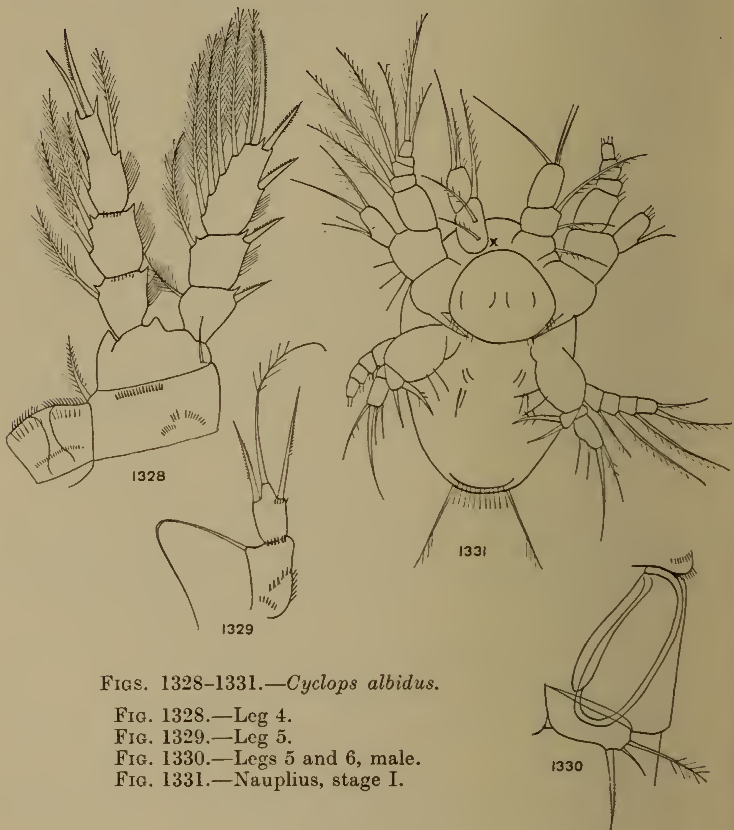
North America : Widely distributed (Marsh, Kiefer, etc.).

South America : Argentine (Brian) ; Paraguay (Daday); Colombia (Thiébaud).

Australasia: New South Wales (Henry); South Australia (Sars); New Zealand (Kiefer); Hawaii (Sars).

Variation.

Kiefer (1928, p. 14) has described a subspecies *C. a. oligolasius*, from the Linjanti river at its entrance to



Figs. 1328–1331.—*Cyclops albidus.*

Fig. 1328.—Leg 4.
Fig. 1329.—Leg 5.
Fig. 1330.—Legs 5 and 6, male.
Fig. 1331.—Nauplius, stage I.

the Zambesi. This form differs from the type only in the complete absence of the distal inner seta of endopod 3 of leg 4. The same form, lacking this seta, is recorded by Sars (1909, p. 53) from Lake Nyasa, and also by Harada from Formosa (1931).

Bionomics.

Found in the same conditions as *C. fuscus*, throughout the year. Lowndes (1928, p. 341) notes its extraordinary adaptability to conditions of surroundings and of temperature. Wolf noted three periods of reproduction, in January and February, June, and October, but egg-bearing females may be taken in any month in the year. Elton (1929) points out that, though found throughout the year, it is very much more abundant in summer.

Cyclops distinctus, Richard.

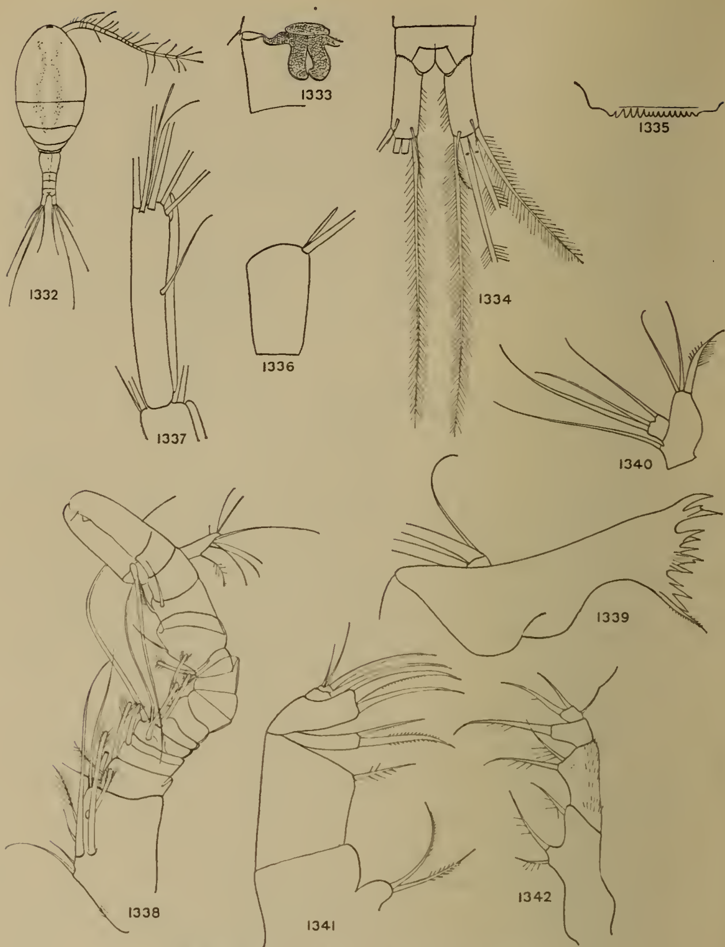
(Figs. 1332–1348.)

1887. *C. tenuicornis* var. *distinctus*, Richard, Bull. Soc. Zool. Fr. XII, p. 162.
1890. *C. gracilicornis*, Lande, Pam. Fizyjogr. X, p. 345, figs.
1898. *C. bistriatus*, Scourfield, Essex Nat. X, p. 325, figs.
1901. *C. distinctus*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 47, figs.
1903. *C. bistriatus*, Scourfield, J. Quek. Mic. Cl. (2) VIII, p. 535.
1908. *C. distinctus*, Van Breemen, Tijds. Ned. Dierk. Ver. (2) X, p. 321, figs.
1913. ,, Neubaur, Zool. Jahrb. Syst. XXXIV, p. 117, figs.
1914. *Pachycyclops bistriatus*, Sars, Crust. Norway, VI, p. 67, figs.
1928. ,, Lowndes, Nat. Hist. Wicken Fen IV, p. 337.
1929. *Macrocyclops distinctus*, Kiefer, Tierreich, Lief. LIII, p. 28.

It is suggested by Scourfield and by Sars that Koch's name, *C. bistriatus*, should be used. The only reason for this is the fact that Koch's figure "applies fairly well to the present form, and also his notes about the colour agree" (Sars). Sars goes on to say that the figure is certainly that of a *Pachycyclops*, and that, as both the other species are recognizable in other figures, this one must represent the remaining species. With this kind of speculation I have no sympathy.

Female.—Length 2·0 mm.

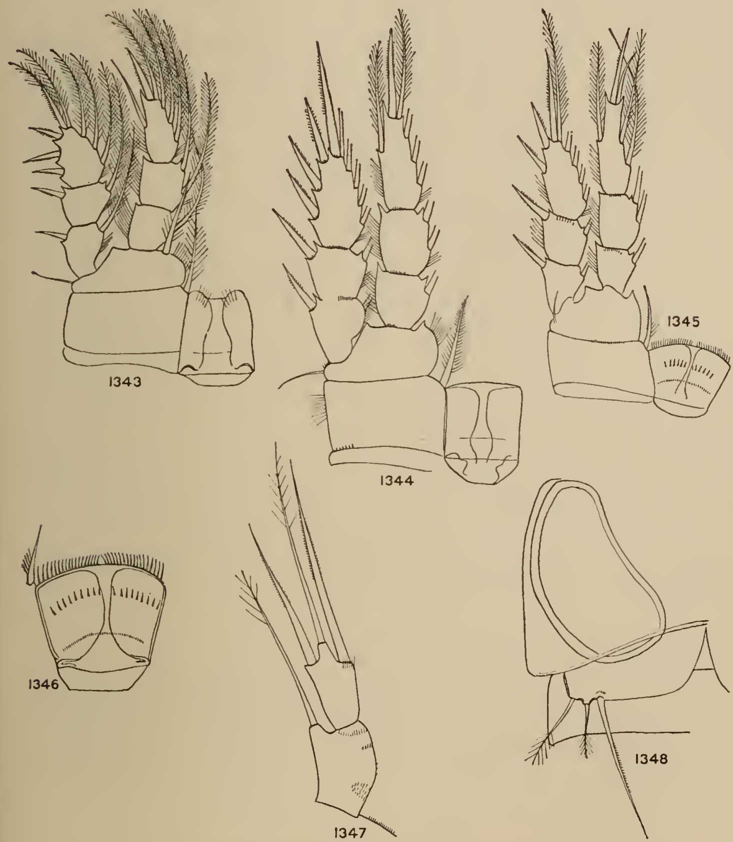
Thorax oval, greatest width in middle; genital somite about as wide as long; receptaculum with posterior part deeply cleft into parallel sacs; usually slightly expanded at posterior ends; lateral arms of posterior part broad; closely resembling that of *C. fuscus*, but without brick-red colour. Furcal rami 3 times as long as wide, with sparse hairs on inner margin; outer seta



Figs. 1332–1342.—*Cyclops distinctus.*

Fig. 1332.—Female, dorsal.
Fig. 1333.—Receptaculum.
Fig. 1334.—Furcal rami.
Fig. 1335.—Upper lip.
Fig. 1336.—Antennule, seg. 12.
Fig. 1337.—Antennule, seg. 17.
Fig. 1338.—Antennule, male.
Fig. 1339.—Mandible.
Fig. 1340.—Maxillule, palp.
Fig. 1341.—Maxilla.
Fig. 1342.—Maxillipede.

about two-thirds length of inner; longest apical seta more than half length of body. According to Neubaur they have a characteristic lyrate curvature, but this is not



Figs. 1343–1348.—*Cyclops distinctus.*

Fig. 1343.—Leg 1.
Fig. 1344.—Leg 3.
Fig. 1345.—Leg 4.
Fig. 1346.—Leg 4, uniting lamella, male.
Fig. 1347.—Leg 5.
Fig. 1348.—Leg 6, male.

always true. Labrum with 12–17 small, equal-sized teeth. Antennule as in *C. albidus*, the lamella of seg. 17 not toothed ; æsthete of seg. 12 longer than in *C. fuscus*, but shorter than seg. 13 ; sensory hair on seg. 16 present,

about $\frac{1}{4}$ length of seg. 17; segs. 8–10 and 12–14 without marginal spinules. Antenna as in *C. albidus*, seg. 3 shorter than seg. 4. Mandible palp without the spiny process of *C. fuscus*; the short seta intermediate in length between *C. fuscus* and *C. albidus*. Maxilla as in *C. albidus*, the inner seta on seg. 2 short and slender. Maxillipede with outer seta on apical segment longer than in preceding species, and with characteristic bend in middle. Swimming-legs without marked specific characters. Uniting lamella of leg 4 as in *C. fuscus*. Neubaur notes that the distal row of spinules on posterior face are stronger, but this I do not find to be the case. He notes also that the margin of the lamella in leg 3 in *C. fuscus* has a row of small spines which is absent from *C. albidus* and *C. distinctus*, but I find it generally absent also from *C. fuscus*. Leg 4 endopod 3 less than 3 times as long as wide; distal inner seta well developed; outer apical spine nearly equal to inner (1·3 : 1) Leg 5 differing from that of *C. fuscus* in the very much longer inner and outer apical spines. Egg-sacs large, not very divergent, but less close to abdomen than in *C. fuscus*.

Colour: Blue, with greenish markings. End of abdomen and antennules purple.

Male.—Length 1·2–1·4 mm.

Without marked differences from preceding species. Spermatophore as in *C. fuscus*, but a little more elongated and with glandular matter distal, leaving spermatozoa free at proximal end.

Distribution in Britain.

Epping Forest (D. J. S.).

Surrey: Kew (D. J. S.).

Norfolk: Fairly common throughout Broads district (R. G.).

Cambridge: Wicken Fen (A. G. L.).

Sussex: Pevensey (D. J. S.).

Suffolk: Upthorpe (D. J. S.).

Kent: Minster (D. J. S.).
Marlborough district (A. G. L.).
Birmingham (A. G. L.).
Scotland: Isle of Jura (R. G.); Skye (A. G. L.).

Distribution Abroad.

France (Richard).
Poland (Lande).
Holland (V. Breemen, R. G.).
Germany (Neubaur, etc.).
Norway (Sars).
Sweden (Lilljeborg).
Russia (Richard).
Ceylon (R. G.).
India, Lahore (R. G.).
New Zealand (Brady).

Kiefer (1932c) has described a species, *Macrocyclops neuter*, from Java, which differs in some details from *C. distinctus*, particularly in the relative lengths of the segments of the antenna. It is probable that records of *C. distinctus* from Ceylon and New Zealand really refer to this form, but whether it should be regarded as a distinct species is quite another matter. I have no longer specimens from Ceylon for comparison, but, after noting certain differences from *C. distinctus*, I concluded at the time (1916) that they did not justify separation. Apart from the difference in the antenna I see no reason to change this opinion.

Bionomics.

This species is found under the same conditions as *C. fuscus* and *C. albidus*, and often in company with both; but Neubaur (1913, p. 59) has given evidence that each species actually has special preferences, such that *C. distinctus* occupies a position intermediate between the two. He was, however, unable to determine exactly the factors involved. Mr. Scourfield has noted that it is a less powerful swimmer than *C. fuscus* or *C. albidus*.

According to Lowndes (1928, p. 458) the hydrogen ion range of the three species is: *C. albidus*, 4·4–9·8; *C. distinctus*, 7·6–8·4; *C. fuscus*, 5·0–8·1.

The resemblance between *C. fuscus*, *C. albidus* and *C. distinctus* has given rise to speculation as to their relationship. Herrick supposed that the two former were merely age-forms of one species—a view which could not survive closer analysis of the differences between them. On the other hand, the fact that *C. distinctus* is in almost all characters intermediate between the other two gave rise to the suggestion that it might be a hybrid. This suggestion was put forward by Schmeil, and has been tested by Neubaur (1913), who dealt exhaustively with the differences between the three forms, and made a number of attempts to cross them in every possible combination. Every such cross failed entirely. The experience of Lowndes (1928B, p. 337) was the same.

Measurements of C. fuscus, albidus *and* distinctus *taken from Neubaur.*

	C. fuscus.		*C. albidus.*		*C. distinctus.*	
	♀.	♂.	♀.	♂.	♀.	♂.
Furcal rami l. : w.	2·3	1·9	2·95	2·33	2·65	2·04
Distal separation of rami	47	..	35	..	50	..
Outer seta : average of 12	283	..	137	..	330	..
2	650	..	597	..	856	..
3	924	..	797	..	1223	..
4	458	..	373	..	512	..
Divergence of setæ 2 and 3	700	350	450	300	500	400
Density of hairs on setæ (number on 100μ)	30–35	..	22	..	25	..
Teeth on labrum	11	12	7	..	17	..
Short seta of mandibular palp	150	..	50	..	100	..
Terminal seta of maxillipede	25	15	50	22	65	35
Æsthete of seg. 12	15	..	50	..	40	..
Total length	2·16	1·22	1·87	1·00	2·18	1·25
Thorax	1·39	8·7	1·2	·85	1·43	·65
Abdomen	·771	·35	·672	·35	·754	·40
Width of thorax	·82	·48	·73	·41	·84	·46
Thorax : abdomen	1·8	2·48	1·7	1·83	1·9	2·12
L. : w.	1·69	1·83	1·64	1·58	1·7	1·85

Subgenus Macrocyclops.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Outer % of inner spine.	Outer spine % of end 3.
C. fuscus :												
Norfolk, ♀	2·08	340	72	2·4	73	149	375	475	245	3·75	162	94
,, ♀	2·3	..	56	2·12	..	..	..	..	..	..	..	..
,, ♂	1·19	400	67	2·0	69	150	310	445	234	3·05	145	89
Jura, ♂	2·13	385	75	2·57	..	140	360	486	245	3·17	152	97
C. albidus :												
Norfolk, ♀	1·5	390	73	2·37	..	126	420	560	232	2·9	126	93
,, ♀	1·8	400	72	2·27	76	93	390	500	262	2·7	128	97
,, ♂	1·13	370	71	2·32	71	88	401	590	301	2·62	128	96
,, ♂	·96	375	64	2·1	71	93	..	..	320	3·45	120	91
Cranleigh, ♀	1·59	400	82	2·76	..	107	395	540	257	2·72	128	100
C. distinctus :												
Norfolk, ♀	2·0	410	87	3·3	82	180	..	600	275	2·95	131	90
,, ♂	1·21	..	73	2·23	72	165	..	..	280	2·66	144	94
,, ♂	1·4	390	64	1·75	..	240	390	570	300	2·9	152	95

Neubaur's paper is an excellent example of careful comparison and patient experiment. I have not included in my account all the differences observed, but give in tabular form such numerical differences as he noted. The evidence for hybridism brought forward by Braun (1909) from the number of chromosomes is contradicted by Stella (1931), who found the number identical in all three species. All the evidence, both of occurrence in nature, of breeding experiments and comparison of structure, shows that these are three well-marked species, and the hypothesis of hybridism may be dismissed.

Subgenus **TROPOCYCLOPS**, Kiefer.

1927. Kiefer, Zool. Anz. LXXIII, p. 303.
1929. ,, Tierreich, Lief. LIII, p. 39.
1931. ,, Z. Wiss. Zool. CXXXVIII, p. 487.

Th. som. 5 fringed with hairs; receptaculum with anterior part more or less T-shaped, the arms coiling forwards; furcal rami very short, without lateral spinules. Leg 4 with very long terminal spines. Antennule of male without sense-cylinders. Nauplius not flattened; exopod of antenna with middle segments reduced.

Type.—*C. prasinus*, Fischer, Schmeil.

Until recently *C. prasinus* has been regarded as a member of the "*C. serrulatus*-group," but Kiefer has separated it as a subgenus of *Eucyclops*. The species is so unlike *C. agilis* and its allies in form of rami, prehensile antennule, nauplius and other features that it should at least be treated as requiring a subgenus equivalent in rank to *Eucyclops*. Indeed it is quite probable that its real position is rather with the *C. fuscus*-group than with the Oligarthra. It is only as a matter of practical convenience, and in deference to general opinion, that it is here left in the latter. The subgenus includes at present only one species, of world-wide distribution.

Cyclops prasinus, Fischer, Schmeil.

(Figs. 1349–1373.)

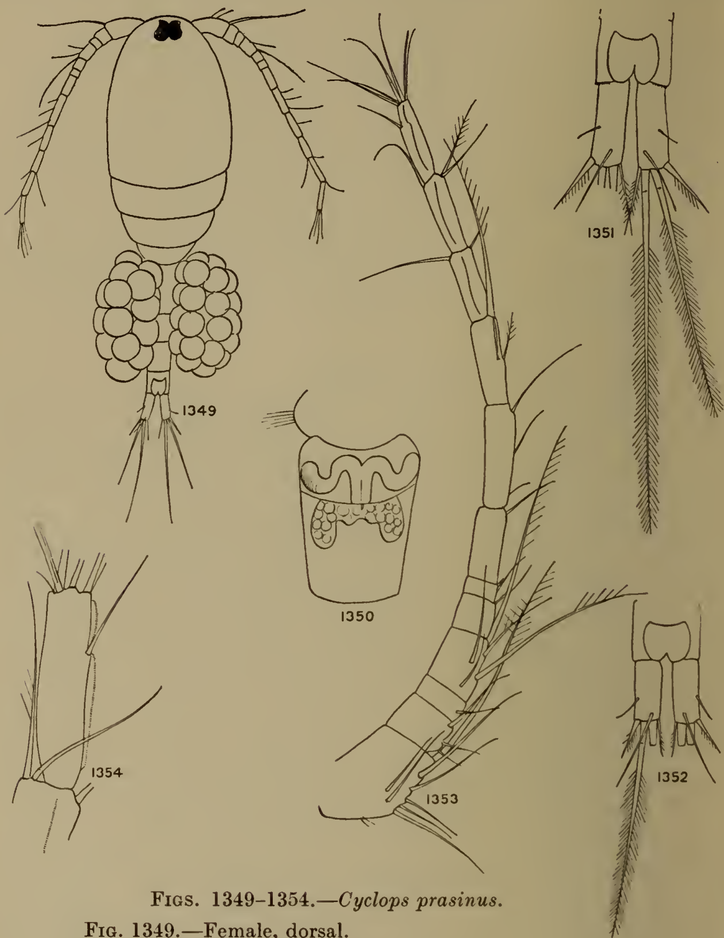
1860. *C. prasinus*, Fischer, Abh. Bayer Akad. VIII, p. 652, figs.
1886. *C. pentagonus*, Vosseler, Jahresh. Ver. Wurt. XLII, p. 212, figs.
1892. *C. prasinus*, Schmeil, Bibl. Zool. Heft XI, p. 150, figs.
1892. *C. magnoctavus*, Brady, Trans. N. H. Soc. Northd. XI, p. 84, figs.
1893. *Eucyclops prasinus*, Claus, Arb. Z. Inst. Wien, X, p. 348.
1906. *C. prasinus*, Van Breemen, Tijds. Ned. Dierk. Ver. (2), X, p. 335, figs.
1919. *Leptocyclops viridis*, Henry, J. R. Soc. N.S.W. LIII, p. 40, figs.
1927. *L. prasinus*, Sars, Ann. S. Af. Mus. XXV, p. 119, figs.
1930. ,, Lowndes, Proc. Zool. Soc. Lond. p. 169.
1930. *Tropocyclops prasinus*, Kiefer, Tierreich, Lief. LIII, p. 39.
1930. ,, ,, Kiefer, Zool. Anz. LXXXVII, p. 118.
1931. ,, ,, Kiefer, Z. Wiss. Zool. CXXXVIII, p. 506, figs.
1931. *E. p. candidiusi*, Harada, Annot. Zool. Japon, XIII, p. 150, figs.
1932. *T. prasinus*, Kiefer, Arch. Naturg. N.F. 1, p. 244, figs.
1932. *L. prasinus*, Lowndes, Ann. Mag. Nat. Hist. (10), X, p. 48.

Female.—Length ·68–·75 mm.

Thorax oval; eye exceedingly large; th. som. 5 fringed with long hairs. Genital somite about $1\frac{1}{2}$ times as long as wide; receptaculum of peculiar form; anterior part consisting of a narrow median portion with 2 S-shaped diverticula*; posterior part narrow in middle, produced backwards on both sides; structure difficult to see owing to deep green pigmentation. Furcal rami 2·3–3 times as long as wide; lateral seta inserted at, or slightly beyond, middle; inner terminal seta equal to, or a little longer than, outer, shorter than ramus, or occasionally equal to it. Setæ 2 and 3 rather short, seta 3 about one-third length of body. Antennule very slender, reaching back beyond 2nd free thoracic somite, of 12 segments, with very long setæ on segs. 1 and 4; last 3 segments very slender, with a very finely serrated hyaline membrane. Sensory hair on seg. 11 about two-thirds as long as seg. 12; æsthete on seg. 9. Antenna long and slender, seg. 4 longer than seg. 3. Mandible with 2 very long setæ and a small hair in place of exopod. Maxillipede slender, seg. 2 profusely hairy on posterior side; two terminal segments of endopod quite distinct. Legs with rami 3-segmented; leg formula 3.4.4.3.† Uniting lamella of legs 1–3

* For variation in form of the receptaculum see Kiefer, 1932c, p. 245.
† See below, p. 91.

slightly concave, that of leg 4 with convex margin, and transverse rows of spinules on surface. Leg 1, coxal



FIGS. 1349–1354.—*Cyclops prasinus.*

FIG. 1349.—Female, dorsal.
FIG. 1350.—Receptaculum.
FIG. 1351.—Furcal rami, dorsal. Norfolk.
FIG. 1352.—Furcal rami, dorsal. Lake Naivasha.
FIG. 1353.—Antennule, female.
FIG. 1354.—Antennule, seg. 12, showing hyaline membrane.

seta very long and feathered; inner seta on basis spine-like, reaching to end of endopod 2. Coxal seta of legs 2–4 rather short and stiff, not feathered at end.

Cyclops prasinus.

Locality.	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.			Leg formula.
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Outer % of inner spine.	Inner spine % of end 3.	
1. Suffolk, Corton . .	·78	320	74	2·7	50	51	225	350	60	2·9	42	168	3.4.4.3
2. Bradford . . .	·70	415	68	2·43	53	56	194	305	56	2·73	45	168	,,
3. Devonshire . .	·75	332	67	2·3	56	55	215	325	67	2·76	42	166	,,
4. Oxford . . .	·78	332	64	2·42	53	58	210	340	57	3·1	40	160	,,
5. Norfolk (Sutton) .	·78	333	64	2·3	53	55	195	305	63	2·4	43	182	
6. E. Africa, Lake Naivasha . . .	·65	370	63	2·32	57	46	231	352	42	2·35	. .	230	3.4.3.3
7. ,, . . .	·63	350	65	2·5	64	40	238	350	33	2·25	25·5	440	,,
8. Ceylon . . .	·56	340	69	2·25	54	52	234	380	43	2·2	41	260	,,
9. ,, . . .	·52	335	67	2·4	53	55	212	. .	40	2·13	40	235	,,
10. Abyssinia . .	·7	357	71	2·53	61	67	285	370	46	3·72	50	180	,,
11. Algeria . . .	·85	354	64	2·5	53	50	222	330	60	2·26	53	165	3.4.4.3
12. France (Gorbio) .	·72	333	60	2·55	53	55	230	365	68	3·55	45	168	,,

Leg 4, endopod 3 nearly or quite 3 times as long as wide; inner apical spine much longer than endopod 3 (1·6 : 1) and nearly twice as long as outer spine. Leg 5 a small

FIGS. 1355–1360.—*Cyclops prasinus.*

FIG. 1355.—Antennule, male, dorsal.
FIG. 1356.—Antennule, male, ventral.
FIG. 1357.—Antenna.
FIG. 1358.—Maxilla.
FIG. 1359.—Maxillipede.
FIG. 1360.—Leg 1.

plate with small spinules on inner margin; bearing 2 setæ and a long slender inner spine. Egg-sacs closely apposed to abdomen.

Colour: Dark green. As Schmeil pointed out, the colour is not in the cuticle, but in the subcutaneous tissues.

Position in swimming: this is a definitely swimming, rather than creeping, form and it swims in a characteristic position on its back, with abdomen flexed almost at right angles, ventrally.

Male.—Length ·55–·6 mm.

Antennule slender, of 17 segments but with segs. 16 and 17 fused. Seg. 1 with very long slender setæ, among which it is most difficult to determine which correspond to the æsthetes of *Macrocyclops* and *Eucyclops*. There are 9 setæ in all, but none of them are markedly modified. One of them (marked A in Fig. 1356) has a terminal brush of very fine hairs, but it does not appear to have the cylindrical blunt-ended form of the other species. Similarly 3 setæ, on segs. 2, 3, 4, have delicate hairs, and may be regarded as corresponding to æsthetes. It seems that, in *C. prasinus*, modification of these setæ into sense-organs has not proceeded so far as in *Macrocyclops* and *Eucyclops*. Segs. 1 and 4 each bear a long slender seta corresponding to the "sense hairs" of Claus. Leg 6 with slender inner spine and two nearly equal feathered setæ.

Variation.

Kiefer in 1929 (Tierreich, p. 39) treated the species in a wide sense, including within it *C. tenellus*, Sars; but in February, 1930, he maintained that four species should be distinguished—*C. prasinus*, Fischer, Schmeil; *C. varicoides*, Brady; *C. tenellus*, Sars; *C. confinis*, Kiefer. Lowndes (May, 1930E) pointed out the discrepancies in descriptions of European forms, particularly with regard to the spine formula, and described a form from Abyssinia having the formula 3.4.3.3, and distinguished also by the absence of a seta from the basis of leg 1. Kiefer (1931), without referring to Lowndes's

paper, but basing his conclusions upon material from thirteen localities in different parts of the world, showed that specimens hitherto referred to "*C. prasinus*" could be divided into at least four species. They fall into two groups, "terni" and "quaterni" according to the spine formula, the former having a formula of 3.4.3.3, and the latter 3.4.4.3. Within these two groups species are separated on the form of leg 4 and the lengths of the furcal setæ. These groups are as follows:

Quaterni.

C. prasinus, Fischer: Europe, Java, New Jersey, Uruguay, Flores, Sumbawa.

C. extensus, Kiefer: New Jersey.

Terni.

C. confinis, Kiefer: Madagascar, E. Africa, S. Africa, Flores, Java.

C. parvus, Kiefer: Guatemala.

C. tenellus, Sars: Tanganyika.

C. varicoides, Brady: Gold Coast.

Within these species he also distinguishes "forms" and subspecies, as follows:

C. prasinus, Fischer, s. str.

C. prasinus forma guwana, Kiefer.

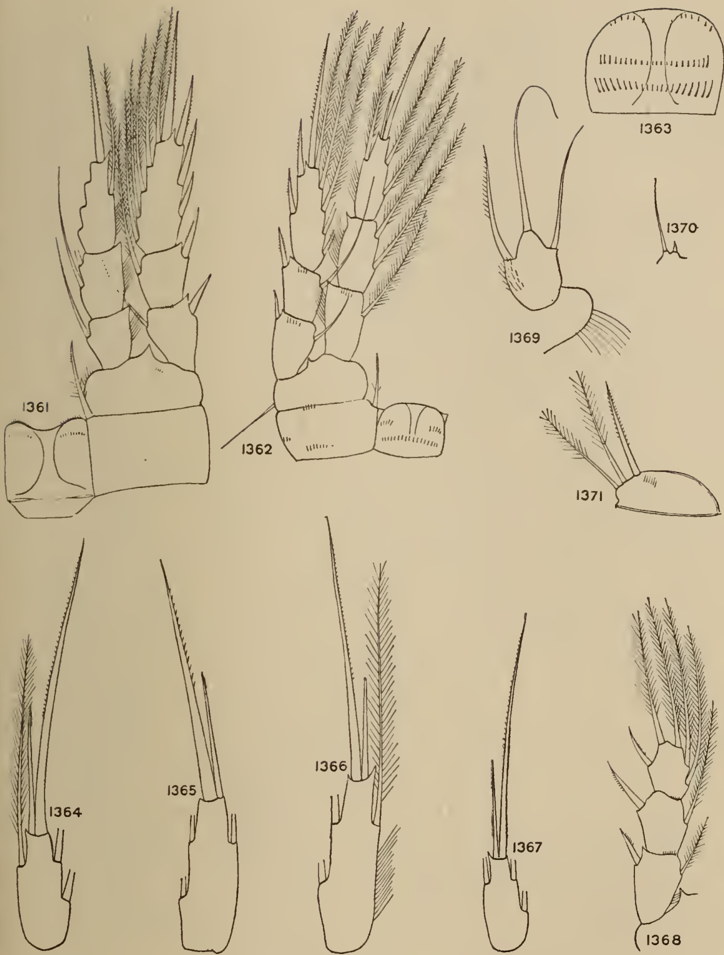
C. prasinus jerseyensis, Kiefer.

C. prasinus meridionalis, Kiefer.

C. extensus forma longispina, Kiefer.

C. confinis forma frequens, Kiefer.

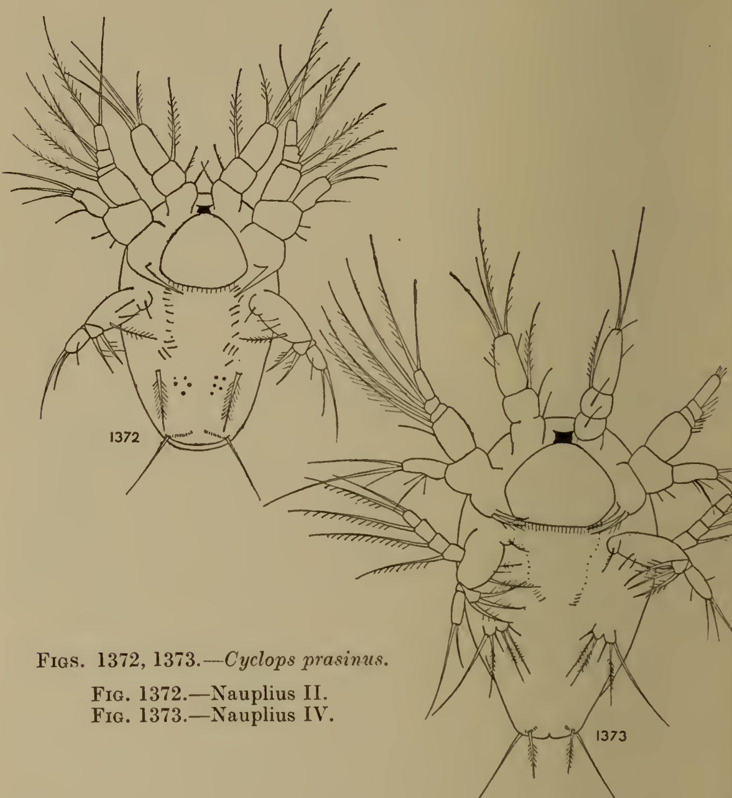
He does not mention whether any of these forms lack, as the Abyssinian form does, a seta on the basis of leg 1 —a point of more importance than the spine formula, since absence of this seta is so rare a phenomenon in *Cyclops*. Kiefer is justified in attaching importance to the spine formula, since this is found to be invariable among individuals of any one population. At the same time we know that it is not a reliable character in some



FIGS. 1361–1371.—*Cyclops prasinus.*

FIG. 1361.—Leg 2.
FIG. 1362.—Leg 4.
FIG. 1363.—Leg 4, uniting lamella.
FIG. 1364.—Leg 4, endopod 3. Lake Naivasha.
FIG. 1365.—Leg 4, endopod 3. Algeria.
FIG. 1366.—Leg 4, endopod 3. Devonshire.
FIG. 1367.—Leg 4, endopod 3. Ceylon.
FIG. 1368.—Leg 3, exopod, abnormal.
FIG. 1369.—Leg 5, female.
FIG. 1370.—Leg 5, copepodid V.
FIG. 1371.—Leg 6, male.

cases (*C. furcifer*, *C. vernalis*), and it cannot command complete confidence as a major character defining species. Further, the species do not appear to have any geographical or biological interest. For example, typical *C. prasinus* and *C. confinis* are recorded by Kiefer from



Figs. 1372, 1373.—*Cyclops prasinus*.

Fig. 1372.—Nauplius II.
Fig. 1373.—Nauplius IV.

the same locality in the island of Flores, and in New Jersey both *C. prasinus* and *C. extensus* occur.

There is a serious difficulty in adopting Kiefer's nomenclature which he does not discuss. While we have no means of knowing the leg formula of the form originally named by Fischer, we do know that Schmeil,

whose description has hitherto been accepted as defining the species, had only specimens with a formula of 3.4.3.3. This is also the formula given by Vosseler. If, then, the formula is distinctive, Kiefer's *C. prasinus* s. str. is not the same as Schmeil's, and, indeed, Schmeil's form apparently corresponds to *C. confinis*, Kiefer. On the other hand, if we have to attach Fischer's name to one of these forms, it must obviously be to that of Schmeil. Here, it seems, is a deplorable confusion in nomenclature which we might well have been spared, and it is difficult to see how to put it right. There seems to be no reason to doubt that races with each leg formula are to be found in Europe, though Kiefer has not met with the "ternus" form, and I have not seen it myself. This rare form would, then, have to take the name *C. prasinus*, Fischer, Schmeil, and the common European form, if it is thought fit to separate it, would require an entirely new name. It seems to me best to suspend judgment until the European "ternus" form can be re-examined, and until we also have information as to leg 1 of the other exotic forms. In the meantime we may accept *C. prasinus* in its wider sense, and regard Kiefer's new species as doubtful synonyms of it. These points have been discussed by Lowndes [1932c, p. 48], who agrees that any subdivision of the species should be suspended for the present. Harada's subspecies *C. p. candidiusi* (1931) differs from the British form in its smaller size (·45 mm.), and in having the outer spine on leg 4 endopod 3 and the inner spine in leg 5 rather shorter.

Distribution in Britain.

A species particularly common in the south of England, but recorded from many localities in England, Scotland, Wales and Ireland. It is a rare species in Scotland, from which there are the following records: Lochaber (Brady); Great Cumbrae, Mallaig, Fort Augustus (D. J. S.); Skye (A. G. L.).

Distribution Abroad.

Europe: Absent from Scandinavia and the far north. Generally distributed over middle and south, and eastward through Russia. Apart from Scotland, its most northern locality appears to be in Holland. I have taken it myself at Oisterwyk (about 51° 50′ N. Lat.).

Asia: Sumatra, Java, Ceylon (Daday); Tonkin (Richard); India, Ceylon (R. G.); China (Brehm); Japan (Harada).

Africa: Algeria (Roy and Gauthier, R. G.); East Africa (Daday, van Douwe, R. G.); West Africa (Richard); Tripoli (Brehm); Lybia (Colosi); Egypt (Chappuis, R. G.); Cameroons (Kiefer); South Africa (Sars); Abyssinia (A. G. L.).

America, North: Canada (Willey); Vancouver (R. G.); United States (Marsh, etc.).

South: Argentine (Brian); Patagonia, Chile (Daday); Honduras (Marsh); Brazil (Van Douwe); Falkland Islands (Scott).

Australian region: New South Wales (Henry); New Hebrides (A. G. L.); New Zealand (Kiefer); Dutch East Indies (Oye).

Distribution is, therefore, mainly in the south. Whatever view may be taken of the limit of the species, the typical form will probably be found to be cosmopolitan.

Bionomics.

Although it is possible to find this species throughout the year, and Kleiber (1911) notes reproduction taking place beneath ice in the Black Forest, it is definitely a summer form. Wolf found two breeding periods—in June and September. Though a free-swimming species, it is not, in this country, a member of the plankton, but is found most commonly in rather small ponds. In America, however, it is common in the plankton of the Great Lakes (Marsh). In Green Lake it is found throughout the year, but with maximum in October and

November (Marsh). Brehm (1909) notes its occurrence in brackish water in Italy, and Thompson (1895) records it as taken in brackish water at Lytham, with *Eurytemora affinis*.

Subgenus **EUCYCLOPS**, Claus.

1893. *Eucyclops*, Claus, Anz. Akad. Wien, no. 9, p. 82.
1914. *Leptocyclops*, Sars, Crust. Norway, VI, p. 70.
1927. *Afrocyclops*, Sars. Ann. S. Af. Mus. XXV, p. 121.
1927. *Eucyclops* s. str. Kiefer, Zool. Anz. LXXIII, p. 303.
1929. ,, ,, Kiefer, Tierreich, Lief. LIII, p. 31.

Th. som. 5 fringed with hairs; receptaculum with anterior and posterior parts narrow, generally with more or less concave outline. Furcal rami generally long and slender, and with denticles on outer margin; outer apical seta spine-like. Antennule of 11 or 12 segments, segs. 10–12 generally (? always) with hyaline membrane. Nauplius flattened, sharply constricted behind, with strong furcal spines.

Type.—*C. agilis*, Koch, Sars.

Key to the British Species of Eucyclops.

1. Antennule seg. 12, membrane in proximal half smooth or minutely serrated . . . . 2.
   This membrane distinctly broken into separate teeth 4. (*C. macruroides.*)
2. Antennule segs. 10–12 very long and slender; rami of female with " saw-like " row of denticles . 3. (*C. agilis.*)
   These segments not very slender; rami very long, with obliquely arranged group of spinules distally *C. macrurus.*
3. Rami generally not more than 5 times as long as wide; lateral " saw " conspicuous . . . *C. agilis* s.str.
   Rami generally more than 5 times as long as wide; lateral denticles very small . . . . . *C. a. speratus.*
4. Membrane of proximal half of ant. seg. 12 with many finely pointed teeth . . . . . *C. macruroides* s. str.
   This membrane with 10–12 large, blunt teeth *C. m. denticulatus.*

The *C. serrulatus*-group.

Whereas Schmeil recognized only two species, *C. serrulatus* and *C. macrurus*, and even felt some doubt

as to the distinctness of the latter, there is now general agreement in admitting both *C. macrurus*, and also four other European species—*C. agilis*, *C. speratus*, *C. macruroides*, *C. lilljeborgi*. In addition to these a large number of exotic species have been described. Kiefer includes 27 species of *Eucyclops* in 'Das Tierreich' (1929), and he has described 7 more since then. So far as concerns the European species there has never been any difficulty in accepting *C. macrurus*, which is at all times easily recognizable, and it is also clear that a distinction must be made between species with smooth antennular membrane (though generally minutely serrated), and those in which it is broken up into spine-like parts; but it is most difficult to form a decided opinion with regard to the status of the two species in each group. In both cases we are dealing with common and very variable forms, and it is easy to draw a distinction between the extreme variants; but in both cases any possible definition breaks down if the many intermediate forms are considered. In both cases there is a common form, and a rare form associated with it. The differences are, at best, very difficult to appreciate. Even in Sars's figures the differences are so small that only the most willing eye can set value on them. My own experience may be unfortunate, or I may be constitutionally unfitted to discriminate between allied species, but I have repeatedly found specimens which I have been unable to refer to one or other of these "species." I find also, from examination of old material, that I have several times named as *C. m. denticulatus* (*C. lilljeborgi*) specimens which I now refer to *C. macruroides*, s. str. In these circumstances it seems to be futile to recognize these forms as species. On the other hand, in deference to the authorities who do not hold this view, I have figured and described them under their accepted names, but as subspecies. It is advisable, when possible, to distinguish these forms, since there may prove to be biological significance in them, but it is, I think, more scientific and less likely to lead to error, if all are referred

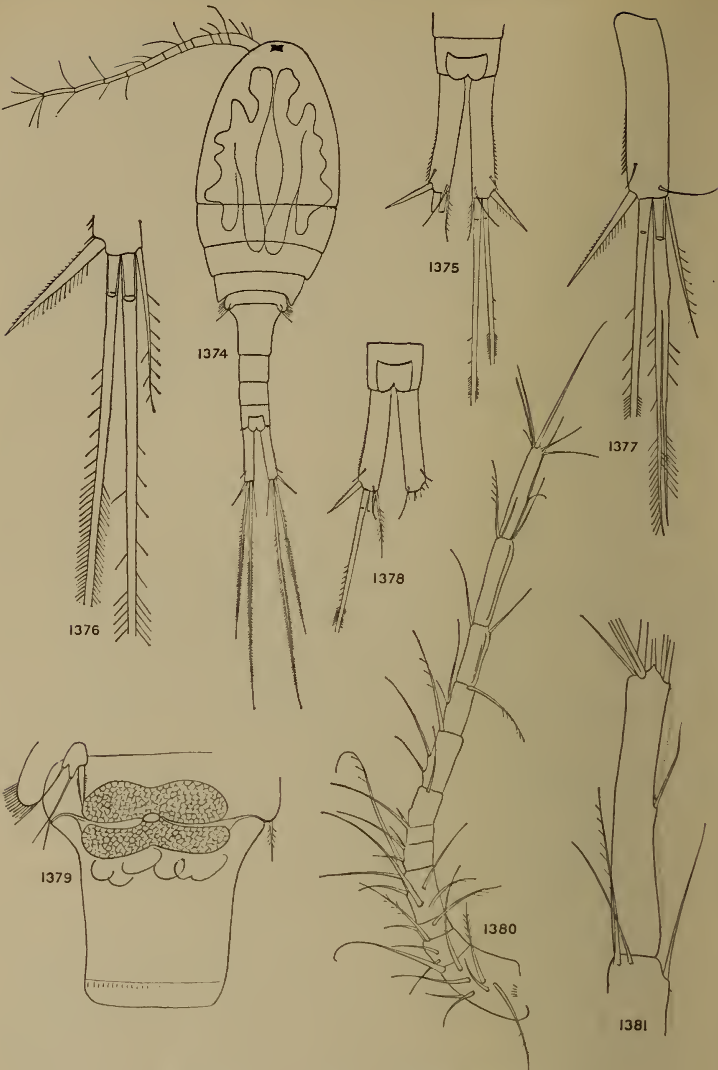
to two major species when there is the smallest doubt about them, rather than that it should be thought necessary to fit every specimen to a definition with which it may not precisely agree. In view of the variability of the European forms, and their marked overlap, a certain amount of doubt must attach to those species from abroad which have been described from very scanty material. One of them, *C. agiloides*, Sars, has been repeatedly recorded from various parts of Africa, but Lowndes (1932c), having knowledge of the variability of European forms, and sufficient material of *C. agiloides*, concludes that it is not distinct from *C. agilis*.

Cyclops agilis, Koch, Sars.

(Figs. 1374–1394.)

1838. *C. agilis*, Koch, Deutschl. Crust. Myr. Arach. Fasc. 21, no. 3.
? 1851. *C. serrulatus*, Fischer, Bull. Soc. Mosc. XXIV (2), p. 423, figs.
1863. ,, Lubbock, Trans. Linn. Soc. XXIV, p. 197.
1878. ,, Brady, Mon. Brit. Cop. I, p. 109, figs.
1892. ,, Brady, Trans. N. H. Soc. Northd. XI, p. 83, figs.
1892. ,, (part), Schmeil, Bibl. Zool. XI, p. 141, figs.
1893. *Eucyclops serrulatus*, Claus, Anz. Akad. Wien, no. 9, p. 82.
1901. *C. varius*, vars. *proximus* and *brachyurus*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 89, figs.
1909. *Cyclops agiloides*, Sars, Proc. Zool. Soc. Lond. p. 59, figs.
1914. *Leptocyclops agilis*, Sars, Crust. Norway, VI, p. 71, figs.
? 1926. *L. brevifurcatus*, Grandori, Boll. Ist. Zool. Rome, III, p. 45, figs. (Copepodid, stage V).
1927. *C. serrulatoides*, Labbé, Arch. Zool. Exp. LVI, p. 200, figs.
1929. *Eucyclops serrulatus* and *E. agiloides*, Kiefer, Tierreich, Lief. LIII, p. 31.
1932. *L. agilis*, Lowndes, Ann. Mag. Nat. Hist. (10), X, p. 45.

The correct name for this species cannot now be determined, and is simply a matter of opinion. There are three possible names—*C. agilis*, Koch, *C. serrulatus*, Fischer, *C. varius*, Lillj. Neither Koch's nor Fischer's figures suffice to show to which of the four species, into which *C. serrulatus*, Schmeil has been divided, they refer. Lilljeborg, who first divided the species, regarded the form later described by Sars as *C. lilljeborgi* as Fischer's species, while Sars identified the latter with *C. varius* var. *brachyurus*, Lillj. He, however, abandoned Fischer's name in favour of *C. agilis*, Koch.



FIGS. 1374–1381.—*Cyclops agilis.*

FIG. 1374.—Female, dorsal.
FIG. 1375.—Furcal rami, dorsal.
FIG. 1376.—Apex of ramus.
FIG. 1377.—Abnormal ramus, with bifurcated seta 3.
FIG. 1378.—Rami of " *C. agiloides.*" Abyssinia.
FIG. 1379.—Receptaculum.
FIG. 1380.—Antennule.
FIG. 1381.—Antennule, seg. 12.

Thallwitz (1927) accepted neither Koch's nor Fischer's names for Sars's *C. agilis*, but adopted *C. varius*, Lillj. Finally, Kiefer has restored *C. serrulatus*, Fischer, for this species. The various methods of treatment are set out here in tabular form. Confusion could no

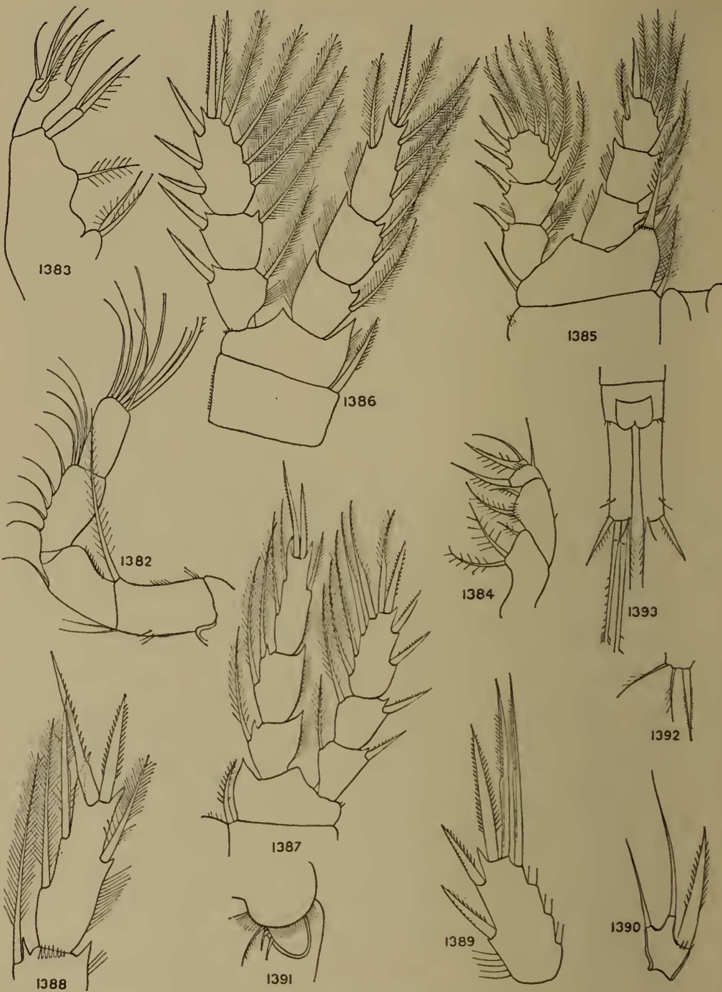
Lilljeborg, 1902.	Sars, 1914.	Thallwitz, 1927.	Kiefer, 1929.
C. serrulatus	*C. lilljeborgi*	*C. denticulatus*	*C. lilljeborgi*
C. macruroides	*C. macruroides*	*C. macruroides*	*C. macruroides*
C. varius :			
var. *speratus*	*C. speratus*	..	*C. speratus*
var. *proximus* var. *brachyurus*	*C. agilis*	*C. varius*	*C. serrulatus*

further go ! So far as Koch's and Fischer's descriptions go, all that can be said for them is that probably both were dealing with the same common form—*C. agilis*, Sars. If either is to be taken as authority, *C. agilis*, Koch, obviously has priority. Further, *C. serrulatus*, Fischer, has been used in at least three different senses, and, although now adopted by Kiefer, must always remain ambiguous. Koch's name in itself has no meaning, but it is backed by the authority and description of Sars, and, not having been applied to any other form, has no ambiguity. For that reason I adopt it, though *C. varius*, Lillj., would in some ways be preferable, especially as I am here accepting Lilljeborg's limitation of the species ; but the balance of general convenience seems to be in favour of *C. agilis*.

Schmeil mentions a var. *montana*, Brady, but Brady did not, so far as I can find, name the form which he refers to as a mountain variety. It is a little hard that Schmeil should (1892, p. 145) criticize him for giving a name which, it seems, existed only in Schmeil's imagination.

Female.—Length ·8–1·45 mm.

Body rather slender, greatest width about one-third of total length ; lengths of thorax, abdomen and rami



FIGS. 1382–1393.—*Cyclops agilis.*

FIG. 1382.—Antenna.
FIG. 1383.—Maxilla.
FIG. 1384.—Maxillipede.
FIG. 1385.—Leg 1.
FIG. 1386.—Leg 3.
FIG. 1387.—Leg 4.
FIG. 1388.—Leg 4, endopod 3.
FIG. 1389.—Leg 4, exopod 3.
FIG. 1390.—Leg 5.
FIG. 1391.—Genital opening, female.
FIG. 1392.—Leg 6, male.
FIG. 1393.—Furcal rami, male.

about 90, 40, 20; cuticle often conspicuously pitted; thoracic somites often separated by deep notches; th. som. 5 fringed with hairs. Abdomen very narrow, the somites with posterior hyaline border finely serrated; genital somite broad in front, greatest width about equal to length; receptaculum with anterior part larger than posterior, and with a deep median concavity. Furcal rami very variable in length. Typically they are 115–120% of total length, 5 times as long as wide,

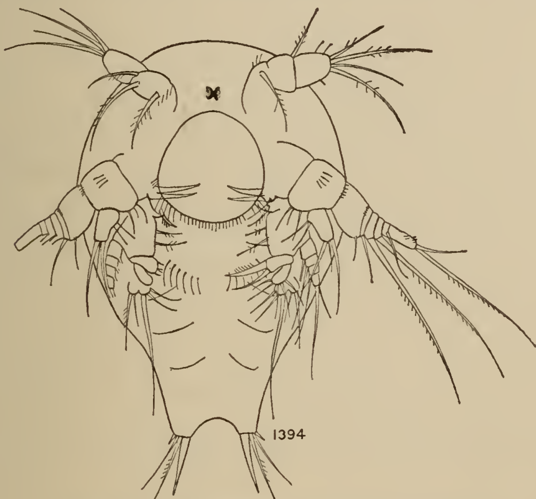


FIG. 1394.—*Cyclops agilis*, nauplius, stage IV.

divergent, and slightly curved outwards; outer margin with longitudinal row of small spines, visible in dorsal view posteriorly, but generally continuing forwards towards ventral surface; lateral seta inserted very near end, and on dorsal surface; outer apical seta stout and spine-like, with long hairs on inner side, and small denticles on outer edge; inner seta much shorter than ramus, and less than twice as long as outer spine; setæ 2 and 3 very long, with a few stiff bristles in basal part, but clothed distally with a double row of short stiff hairs very closely placed. Antennule of 12 segments, reaching generally just beyond th. som. 2;

last 3 segments very long and slender, with a broad hyaline membrane. The edge of this membrane appears to be smooth, but, with high powers, it is generally found to be very minutely serrated. Seg. 10 with hair-like æsthete ; surface of cuticle of proximal segments often pitted. Antenna with distal segment a little shorter than seg. 3. Maxillipede short and stout ; coxa shorter than basis ; the 2 distal segments of the endopod not distinctly separated. Coxa of swimming-legs with very stout inner seta, armed with stiff bristles ; rami 3-segmented, with formula 3.4.4.3. Schmeil states that it may be 3.4.3.3, but this I have not seen. Outer spines coarsely denticulate ; in legs 3 and 4 one or more of the terminal setæ may be peculiarly modified (Fig. 1389). Leg 4, endopod 3 long and slender, the length nearly, or quite 3 times the width ; terminal spines coarsely denticulate, the inner longer than the outer (1·2–1·5 : 1). These spines are often very divergent, the inner turned sharply inwards ; setæ not reaching nearly to ends of spines. Leg 5 a simple plate bearing a broad inner spine and 2 slender setæ ; shape of plate variable. Egg-sacs (in life) rather divergent, pointed at end.
Colour variable, from colourless to deep yellow.

Male.—Length ·68–·8 mm.

More slender than female ; furcal rami without lateral denticles, shorter than in female, and generally more or less parallel, less than 100°/₀₀ of body length and 3–4 times as long as wide. Inner furcal seta longer than ramus. Leg 6, inner spine longer than abd. som. 2, and longer than the 2 outer setæ.

Cyclops agilis speratus, Lilljeborg.

(Figs. 1395–1405.)

1901. *C. varius* var. *speratus*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 88, figs.
1914. *Leptocyclops speratus*, Sars, Crust. Norway, VI, p. 72, figs.
1929. *Eucyclops speratus*, Kiefer, Tierreich, Lief. LIII, p. 33.
1932. *L. speratus*, Lowndes, Ann. Mag. Nat. Hist. (10), X, p. 50.

Female.—Length 1·0–1·42 mm.

Furcal rami parallel, 6–8 times as long as wide, and about 150°/₀₀ of body length; lateral denticles very small, and not reaching beyond middle of ramus; inner apical seta about 60% of length of ramus, shorter than in *C. agilis*.

Male.—Length ·75–·8 mm.

Rami more than one-tenth of body length, and 4–6 times as long as wide; inner furcal seta shorter than ramus.

Certain other characters, in addition to those given above, are adduced by Sars as distinguishing this form from *C. agilis*, but, even with his admirable figures, these differences are scarcely appreciable, and are quite inapplicable in practice. Lowndes (1932c) has discussed the validity of these allied forms. Attempts to cross *C. agilis* and *C. agilis speratus* proved them to be mutually infertile, while crosses between varieties of *C. agilis* were always successful. On the other hand, detailed comparison of structure led to the conclusion that, in respect of every distinguishing character, there are transitions, and no sharp distinction is possible. The male is, however, less variable than the female, and distinction does seem in this sex to be possible. My own observations agree entirely with those of Lowndes. While it is possible to recognize the extreme form of *C. a. speratus* by its long parallel rami, intermediate forms which it is practically impossible to refer definitely to either form are so common that it is impracticable to maintain two species. The overlap is shown in the table of measurements. There is no evidence of any clear ecological distinction. The most that can be said is that *C. agilis* is a species of the widest tolerance, found in every possible situation, while *C. a. speratus* is comparatively rare, and seems to be confined to clear weedy waters. The fact that the two forms are not syngamic shows that there is a physiological distinction which should not be ignored; but the facts can

Cyclops agilis *and* C. a. speratus *arranged in Order of Length of Furcal Rami.*

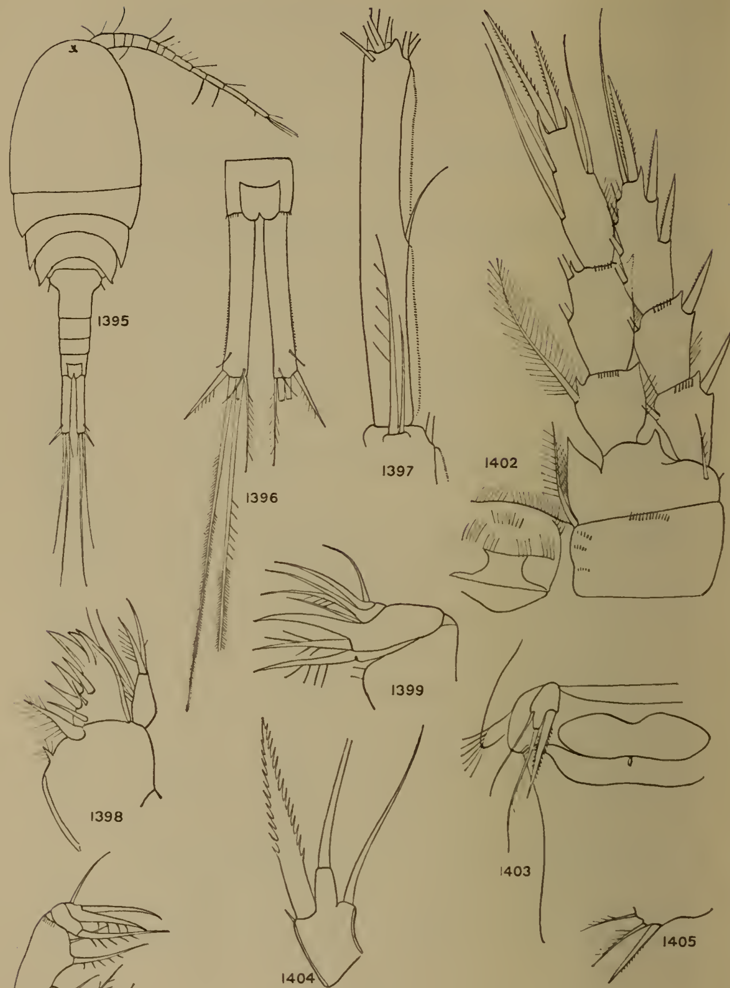
	Body.		Furcal rami.		Furcal setæ.				Leg 4. Endopod 3.			Name.*	Seta 4.
	Length.	Width.	Length.	L. : w.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.		% of ramus.
1. Ringwood (Well.) . .	·8	350	75	4·3	39	425	480	65	2·35	143	100	A	86
2. ,, . . .	·96	310	104	4·5	52	280	440	83	2·32	165	94	A	80
3. Boar's Hill . . .	1·45	282	111	5·8	62	240	365	65	3·0	135	100	A	56
4. Cothill . . .	1·21	323	116	5·2	58	280	445	78	2·7	153	107	A	62
5. Norway . . .	1·28	350	117	4·5	78	313	470	93	2·85	140	100	A	79
6. Breckles . . .	·90	333	117	4·0	78	333	540	93	2·70	140	94	A	79
7. Ingham . . .	1·07	350	122	5·3	65	300	550	97	2·45	134	100	A	79
8. Brunstead . . .	·91	361	120	4·2	71	280	450	93	2·5	141	100	A	81
9. Birmingham . .	1·22	330	123	6·0	57	254	483	78	1·88	155	94	S	64
10. Norway . . .	1·05	360	123	5·2	67	342	540	85	2·93	137	93	A	69
11. Holt	·89	360	124	4·65	78	325	528	100	3·32	143	100	A	79
12. Loch Ard . . .	1·2	315	125	6·0	58	275	410	73	2·2	155	107	?	58
13. E. Africa, L. Naivasha .	·91	340	126	4·6	68	362	. .	97	2·6	148	110	*C. a.*†	77
14. R. Nile, Shubluka .	·95	340	126	4·85	68	306	450	84	2·32	168	106	*C. a.*	67
15. Algeria . . .	·96	342	125	4·35	62	302	490	93	2·46	174	108	A	74
16. Ireland . . .	1·27	355	126	5·3	59	330	. .	87	3·4	129	88	A	69
17. Barton . . .	1·25	320	129	5·9	60	172	255	74	3·1	147	94	A	57
18. Herringfleet . .	1·15	330	130	5·6	57	305	450	54	2·9	121	103	A	42
19. N. Wales . . .	1·27	345	130	6·4	56	323	485	94	3·1	148	102	A	71
20. Loch Lomond . .	·98	346	131	5·0	73	366	530	82	2·8	144	101	?	62
21. Ormesby . . .	1·27	330	134	5·5	63	339	510	103	3·0	133	97	S	77
22. Larling . . .	1·10	320	138	4·5	63	190	330	90	2·8	146	106	A	65

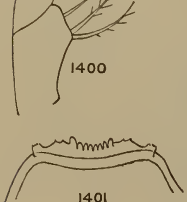
23. Greece, Delphi . .	·88	340	140	4·4	46	295	455	80	2·0	126	103	A	57
24. Fritton, Suffolk . .	1·40	..	143	8	57	..	..	85	3·0	116	92	S	63
25. Ingham . . .	1·04	365	144	5·6	67	385	578	93	2·7	140	94	?	64
26. Windsor . . .	1·38	325	148	7·5	54	304	479	94	..	..	..	S	63
27. ,, . . .	1·27	315	145	7·0	63	284	460	75	2·95	191	96	S	52
28. Barton, Norfolk . .	1·42	340	149	7·6	70	310	490	78	2·85	137	105	S	52
29. Birmingham . .	1·32	340	149	7·4	57	305	487	84	3·35	133	103	S	56
30. ,, . .	1·16	335	150	6·8	77	310	480	94	2·35	154	106	S	62
31. Loch of Skaill . .	1·00	330	150	6·2	60	340	510	85	2·8	137	107	S	57
32. Ormesby . . .	1·36	345	154	8·0	63	330	505	88	2·8	146	106	S	57
33. Holland, Naardermeer .	1·18	..	158	6·7	59	310	473	83	2·36	135	93	S	53
34. Friesland, Grouw. .	1·17	340	158	7·5	62	326	479	85	2·8	140	100	S	54
35. ,, ,, .	1·15	..	160	6·6	68	330	530	95	..	..	..	S	59
36. ,, ,, .	1·2	..	175	7·5	58	315	407	92	..	..	..	S	53

Males.

37. Birmingham‡ . .	·79	236	86	3·1	56	329	532	122	2·55	135	96	A	141
38. Hook	·72	290	94	3·67	56	320	..	100	2·32	130	100	A	103
39. Marlborough‡ . .	·78	320	97·5	3·5	61	318	512	102	2·6	135	104	A	103
40. Oxford . . .	·85	305	102	4·4	57	305	530	95	2·6	122	100	A	93
41. Loch of Skaill . .	·81	235	107	4·5	56	320	565	90	3·1	140	103	S	84
42. ,, . .	·77	290	130	5·8	60	337	545	90	3·2	148	106	S	69
43. Fritton, Suffolk . .	·87	287	109	4·4	57	285	517	80	2·9	116	102	S	53
44. Birmingham‡ . .	·81	322	113·5	3·8	59	370	542	98·5	2·53	144	107	S	86
45. Barton, Norfolk . .	·975	297	128	5·1	49	327	..	77	3·23	128	107	S	60

* A = *agilis*. S = *speratus*.
† *C. a.* = *C. agiloides*.
‡ Measurements from Lowndes, 1932c.





FIGS. 1395–1405.—*Cyclops agilis speratus.*

FIG. 1395.—Female, dorsal.
FIG. 1396.—Furcal rami.
FIG. 1397.—Antennule, seg. 12.
FIG. 1398.—Maxillule.
FIG. 1399.—Maxilla.
FIG. 1400.—Maxillipede.
FIG. 1401.—Upper lip.
FIG. 1402.—Leg 4.
FIG. 1403.—Receptaculum.
FIG. 1404.—Leg 5.
FIG. 1405.—Leg 6, male.

best be expressed by treating them as one species, of which the individuals recognizably having the characters of *C. speratus* may be referred to as a subspecies or variety—a return to Lilljeborg's view. Possibly future experiment may succeed in correlating structural differences with habit.

Cyclops macruroides s. str., Lilljeborg.
(Figs. 1406–1419.)

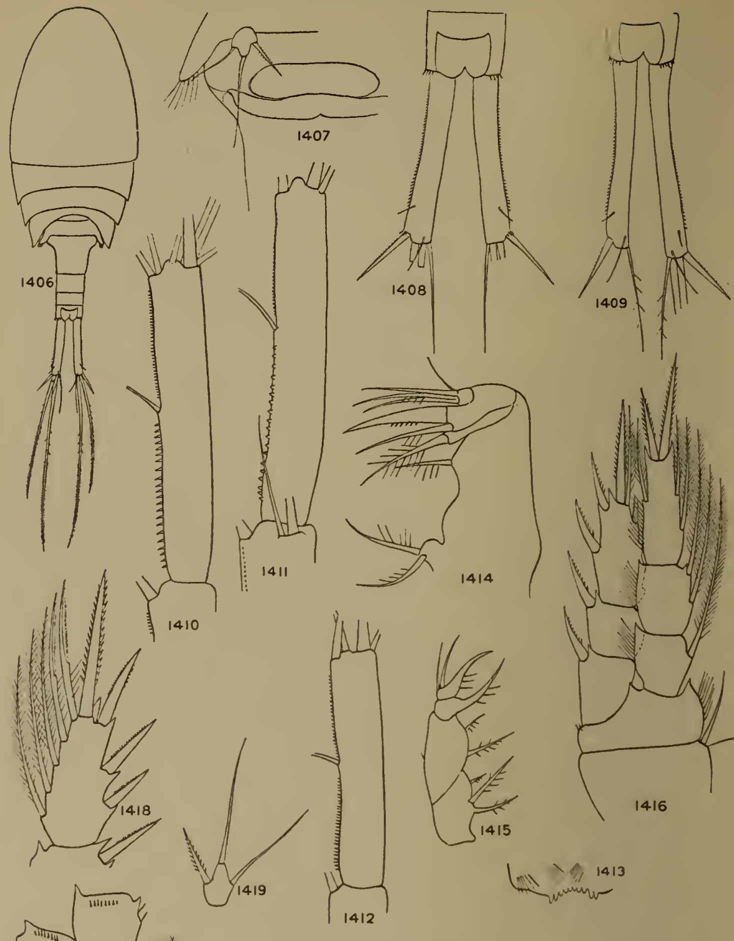
1901. *C. macruroides*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 85, figs.
1914. *L. macruroides*, Sars, Crust. Norway, VI, p. 74, figs.
1929. *Eucyclops macruroides*, Kiefer, Tierreich, Lief. LIII, p. 35.
1932. *L. macruroides*, Lowndes, Ann. Mag. Nat. Hist. (10), X, p. 53.

Female.—Length 1·04–1·25 mm.

General form as in *C. agilis*. Furcal rami 7–9 times as long as wide, with conspicuous outer saw continued nearly to base; outer apical spine with denticulate outer margin; inner seta much shorter than ramus, nearly $1\frac{1}{2}$ times as long as outer spine, and sparsely plumose, sometimes smooth; setæ 2 and 3 either with closely placed stiff short hairs, or with these hairs long and delicate. Segs. 10–12 of antennule with marginal row of very fine pointed spinules; these are stronger in proximal half of seg. 12, and there are 18–30 of them. These proximal spines are typically sharp and numerous, but may be comparatively large, blunt, and fewer in number (18), so approaching closely to *C. m. denticulatus*. Legs with outer spines with stronger marginal spinules than in *C. agilis;* leg 4 endopod 3 about 3 times as long as wide; inner apical spine about equal to endopod 3, and nearly $1\frac{1}{2}$ times as long as outer spine. Leg 5, inner spine much shorter than outer seta, stout and denticulate.

Male.—Length ·68–·81 mm.

Rami 5–7 times as long as wide, without outer saw; outer spine smooth; inner seta shorter than ramus. Leg 6, inner spine very large, about equal in length to middle and outer seta.



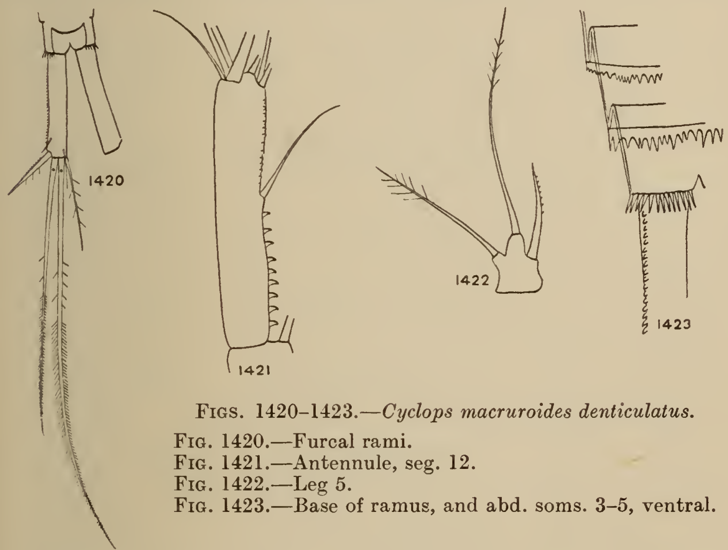
FIGS. 1406–1419.—*Cyclops macruroides* s. str.
FIG. 1406.—Female, dorsal.
FIG. 1407.—Genital somite and receptaculum.
FIG. 1408.—Furcal rami, dorsal.
FIG. 1409.—Furcal rami, asymmetrical.
FIG. 1410.—Antennule, seg. 12. Windermere.
FIG. 1411.—Antennule, seg. 12. Hoveton.
FIG. 1412.—Antennule, seg. 12. Norfolk.
FIG. 1413.—Upper lip.
FIG. 1414.—Maxilla.
FIG. 1415.—Maxillipede.
FIG. 1416.—Leg 4.
FIG. 1417.—Leg 4, coxa and basis from behind.
FIG. 1418.—Leg 4, exopod 3, showing modified setæ.
FIG. 1419.—Leg 5.

Cyclops macruroides denticulatus, Graeter.
(Figs. 1420–1423.)

1901. *C. serrulatus*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 81, figs.
1903. *C. s.* var. *denticulata*, Graeter, Rev. Suisse Zool. XI, p. 491.
1914. *L. lilljeborgi*, Sars, Crust. Norway, VI, p. 73, figs.
1927. *C. denticulatus*, Thallwitz, SB. Ges. Isis, Jg. 1926, p. 4.
1929. *E. lilljeborgi*, Kiefer, Tierreich, Lief. LIII, p. 35.

Female.—Length ·9–1·23 mm.

Furcal rami 6–8 times as long as wide, divergent, often slightly sinuate, with conspicuous outer saw,



FIGS. 1420–1423.—*Cyclops macruroides denticulatus.*
FIG. 1420.—Furcal rami.
FIG. 1421.—Antennule, seg. 12.
FIG. 1422.—Leg 5.
FIG. 1423.—Base of ramus, and abd. soms. 3–5, ventral.

extending nearly to base ; outer apical spine sometimes quite smooth, but generally denticulate outside, and with inner hairs ; inner seta nearly twice as long as outer spine, and nearly as long as ramus. Setæ 2 and 3 as in *C. macruroides* s. str. Antennule seg. 12 with a series of 8–12 large curved spines ; distal part and segs. 10, 11 with much smaller denticles. Legs as in *C. macruroides* s.str. Leg 4 endopod 3 about 3 times as long as wide ; inner apical spine nearly as long as endopod 3, and about 1½ times as long as outer. Leg 5 inner spine much shorter than outer seta, and more slender than in *C. macruroides* s. str.

Cyclops macruroides s. str.

	Body.		Furcal rami.		Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
1. Lake District	1·12	330	178	8·0	73	355	452	108	2·94	147	94
2. Windermere	1·05	..	162	7·4	58	315	410	86	3·0	134	106
3. Jura	1·07	326	164	7·7	75	336	..	122	3·13	137	96
4. North Wales	1·23	355	163	7·8	65	325	440	89	2·85	132	97
5. Mallaig	1·06	330	168	7·6	67	340	490	113	2·55	165	104
6. Breckles, Norfolk	1·06	330	170	8·0	66	330	450	94	3·06	138	110
7. Birmingham ♂*	·76	289	147	6·2	74	302	474	129	2·38	133	116
8. ,, ♂*	·76	289	132	5·0	76	329	447	121	2·38	135	112
9. Naardermeer, Holland	1·1	345	182	9·3	77	360	..	107	2·82	138	97
10. ,, ,,	1·04	365	165	8·0	77	382	..	96	..	..	..
11. ,, ,,	1·05	..	171	9·2	71	370	475	114	3·1	140	100

C. m. denticulatus.

1. Sutton, Norfolk	·9	375	145	6·2	67	355	510	133	2·85	148	93
2. ,, ,,	·94	330	149	7·5	64	340	434	127	3·2	150	100

* Measurements from A. G. Lowndes, 1932.

Much the same difficulty is found in estimating the validity of *C. m. denticulatus* as in that of *C. a. speratus*. In separating *C. serrulatus* (= *C. lilljeborgi*, Sars) from *C. macruroides*, Lilljeborg laid stress chiefly upon the length of the rami, and not at all upon that of the furcal setæ, which he said were the same in both. Also no distinction is drawn between the denticulation of the antennular membrane, since in *C. serrulatus* it is said to have "aculei minutissimi," and in *C. macruroides* "series perspicuam aculeorum tenuissimorum et numerosorum." Sars also makes the distinction rest upon the length of rami and size, but gives also a small difference in thickness of inner spine on leg 5. His figures of the antennule reveal scarcely any difference. Graeter, in describing his var. *denticulata*, says that a slender spine on leg 5 is always associated with a denticulate membrane, and that the teeth of this membrane are backwardly curved and 10–12 in number. As compared with typical *C. serrulatus* (= *C. agilis*, Sars) the inner furcal seta was much longer as a rule. Graeter also noted another form in which the antennular membrane had about 20 finer teeth and a shorter antennule. Length of rami is a character almost without value, and, if we had only the descriptions of Lilljeborg and Sars, one would be disposed to unite these two forms entirely. Graeter's description does, however, introduce a clear and positive difference with regard to the antennular membrane, and this difference is certainly a reliable character. There seems to be a good deal of variation in the number and size of the teeth in *C. macruroides* s. str., though some allowance must be made for the difficulty of seeing these small structures clearly; but I find, very rarely, a form exactly agreeing with Graeter's description, in which the teeth are few and conspicuously large. It is this form which I name here *C. m. denticulatus*, as Graeter's name has priority, and his description is by far the most precise. I have, in the past, unfortunately relied upon Sars's description, and have named as *C. lilljeborgi*

specimens with denticulate membrane and relatively short rami. I have been able, in a few cases, to re-examine the specimens, and find they are really *C. macruroides* s. str. It seems probable that others have made the same mistake, and that all records of "*C. lilljeborgi*" should be regarded as suspect until they have been confirmed by reference to Graeter's description. As Thallwitz points out (1926, p. 10), the males of these forms differ more than the females with regard to the lengths of the furcal setæ, and are therefore more easily separated, but the males do not offer the antennal membrane as a primary means of separation, and some reliance has to be placed on that most unsafe character—the length of the rami. It is far from easy, for example, to separate the male of *C. macruroides* from that of *C. macrurus*, while the females are distinguishable at a glance.

Cyclops macruroides s. lat.

Distribution in Britain.

Scotland: A common species. Many records from the north and west, *e. g.* Skye (A. G. L.); Loch Shin, Loch Ness (R. G.); Loch Awe, Loch Lomond (R. G.).

Lake district: Windermere, etc. (R. G.); Brothers Water (D. J. S.).

Norfolk: Broads district, fairly common (R. G.).

Berkshire: Kennington (R. G.).

Bucks: Farnham Royal, Burnham Beeches (R. G.).

Hampshire: New Forest (D. J. S.).

Devonshire: Clyst (R. G.).

Yorks: Sheffield (R. G.).

Warwick: Birmingham (A. G. L.).

Wiltshire: Marlborough (A. G. L.).

Isle of Man (D. J. S.).

The only locality from which specimens of *C. m. denticulatus* have been available is Sutton Broad, Norfolk.

Distribution Abroad.

Generally distributed throughout Europe.

Asia: Manchuria, Eastern Asia (Rylov); Syria (Kiefer).

Algeria (Roy and Gauthier).

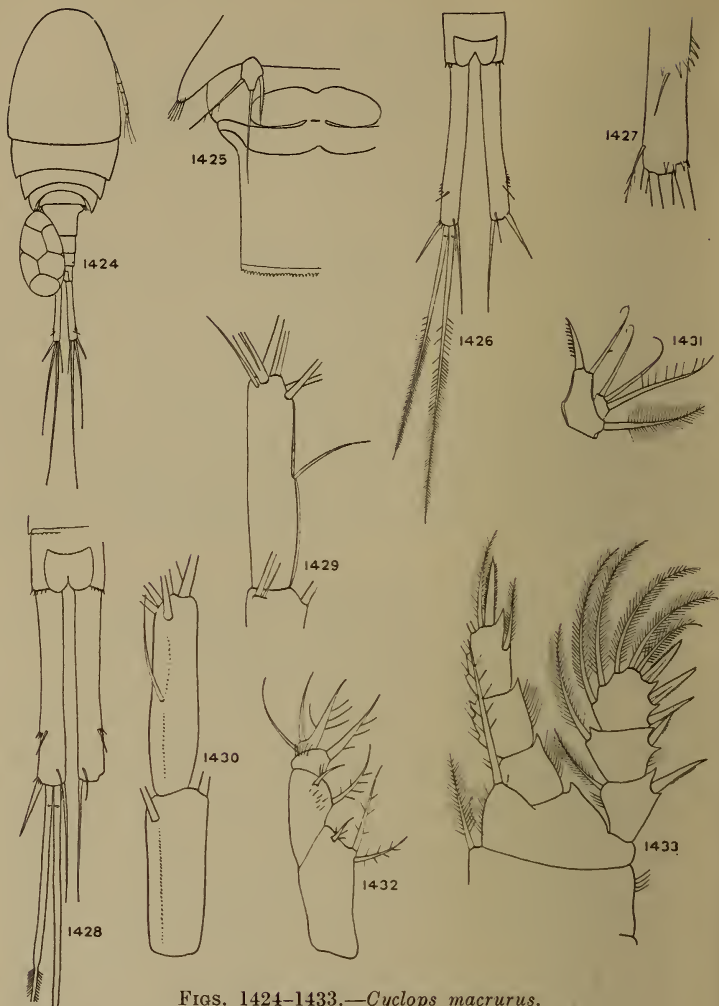
Cyclops macrurus, Sars.

(Figs. 1424–1437.)

1863. *C. macrurus*, Sars, Forh. Vid. Selsk. Christ. 1862, p. 254.
1878. ,, Brady, Mon. Brit. Cop. I, p. 111, figs.
1889. *C. maarensis*, Vosseler, Arch. Naturg. LV, i, p. 118, figs.
1892. *C. macrurus*, Schmeil, Bibl. Zool. XI, p. 146, figs.
1892. ,, Brady, Trans. N. H. Soc. Northd. XI, p. 84, figs.
1914. *Leptocyclops macrurus*, Sars, Crust. Norway, VI, p. 75, figs.
1929. *Eucyclops macrurus*, Kiefer, Tierreich, Lief. LIII, p. 36.
1931. *C. macrurus* var. *caucasicus*, Schiklejew, Zool. Anz. XCIV, p. 190, figs.

Female.—Length 1·1–1·2 mm.

Th. som. 5 fringed with hairs; genital somite wide in front, constricted behind; receptactulum as in *C. agilis*, but anterior part very narrow. Abdominal somites finely serrated. Furcal rami very long and slender, 8–9 times as long as wide; without marginal saw, but with a group of 4 or 5 obliquely arranged spines at insertion of lateral seta; outer apical spine generally smooth; inner seta about half length of ramus, generally smooth; seta 2 generally with closely placed short stiff hairs; seta 3 either with short stiff hairs or with long fine hairs. Antennules shorter than cephalothorax, of 12 segments, the terminal segments not greatly elongated as in *C. agilis*, and with a very narrow, scarcely visible membrane on seg. 12. This membrane may appear smooth, or broken into very fine hairs (Figs. 1429, 1430). Sensory hair of seg. 11 very short. Maxillipede with two terminal segments quite distinct. Swimming-legs as in preceding species. Leg 4, endopod 3 about 3 times as long as wide; inner apical spine not much longer than outer, both spines with strong marginal



Figs. 1424–1433.—*Cyclops macrurus.*

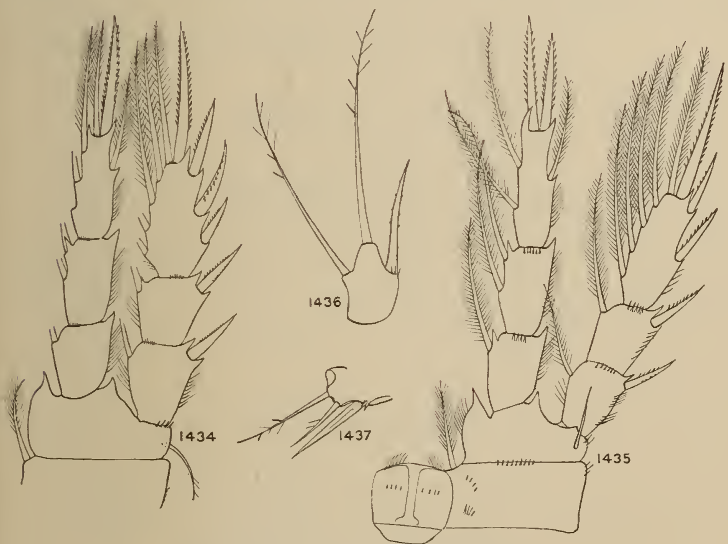
Fig. 1424.—Female, dorsal.
Fig. 1425.—Genital somite.
Fig. 1426.—Furcal rami, female.
Fig. 1427.—Ditto, apex, seen obliquely.
Fig. 1428.—Furcal rami, male.
Fig. 1429.—Antennule, segs. 11 and 12.
Fig. 1430.—The same, showing row of denticles in place of membrane.
Fig. 1431.—Maxillule, palp.
Fig. 1432.—Maxillipede.
Fig. 1433.—Leg 1.

denticles; uniting lamella convex. Leg 5: inner spine much shorter than outer seta, and comparatively slender. I have not seen it as short as it is represented by Sars. Egg-sacs close to abdomen, very small.

Colour yellow.

Male.—·8 mm.

Antennule as in *C. agilis*. Furcal rami about 8 times as long as wide; outer spine and inner seta smooth. Leg 6: inner spine longer than middle seta.



FIGS. 1434–1437.—*Cyclops macrurus.*

FIG. 1434.—Leg 3.
FIG. 1435.—Leg 4.
FIG. 1436.—Leg 5.
FIG. 1437.—Leg 6, male.

VARIATION.

Graeter (1907) has described a var. *subterranea* from caves in Switzerland, which has since been given the specific name *C. graeteri*, Chappuis. This form differs from *C. macrurus* only in the rather shorter rami (6 : 1), the reduction of the lateral spinules of the ramus to 4 short hairs, and the absence of hairs from th. som. 5.

Cyclops macrurus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end 3.
1. Hoveton, Norfolk . .	1·1	345	178	9·2	78	56	265	352	100	3·0	126	118
2. Lough Erne . . .	1·13	310	188	10·0	78	62	265	360	98	3·3	113	100
3. ,, ♂ . .	·8	275	162	8·5	75	51	260	405	100	2·7	112	112
4. Grouw, Friesland . .	1·19	295	168	9·5	77	50	262	..	88	2·86	113	103
5. ,, ♂ .	·81	310	172	9·0	..	52	295	430	108	2·7	124	112

Another very closely allied form is *C. neumanni*, Pesta, from Argentina, which differs mainly in the short inner furcal seta. Schiklejew has proposed a var. *caucasicus*, but I am unable to find in his description any differences whatever from the typical form.

Distribution in Britain.

A rather uncommon species, but so widely distributed that it is unnecessary to give the records. I have notes of its occurrence in Norfolk from 13 localities, in every month from February to November.

Distribution Abroad.

Europe : Generally distributed.
Asia : Central Asia (Sars) ; Palestine (Kiefer).
Africa : Algeria (Roy and Gauthier) ; Egypt (Daday) ; East Africa (Daday).
America : Colombia (Thiébaud) ; Patagonia (Daday).

Subgenus **PARACYCLOPS**, Claus.

1893. Claus, Anz. Akad. Wien, no. 9, p. 83.
1914. *Platycyclops* (part), Sars, Crust. Norway, VI, p. 76.
1927. Kiefer, Zool. Anz. LXXIII, p. 304.
1929. Kiefer, Tierreich, Lief. LIII, p. 40.

Body flattened, without marked constriction between thorax and abdomen. Th. som. 5 with fringe of hairs. Furcal rami usually with spinules running obliquely from lateral seta forwards on to dorsal surface. Antennules short, with not more than 12 segments. Legs 3-segmented ; endopod 2 of leg 1 with 1 seta. Leg 5 unsegmented, with median spine and 2 setæ.

Type.—*P. fimbriatus* (Fischer).

Claus originally included in this genus *C. affinis*, *C. fimbriatus* and *C. phaleratus*, but later established a

new genus *Heterocyclops* for the former. In 1904 Brady made a genus *Ectocyclops* for *E. rubescens*, a species which cannot be distinguished from *C. phaleratus*. The definition of the genus is such as would include also *C. affinis* and *C. fimbriatus*. In 1914 Sars, ignoring all previous work, united the three species in one new genus, *Platycyclops*. Finally, Kiefer (1927) restored Claus's *Paracyclops* for *C. affinis* and *C. fimbriatus*, and placed *C. phaleratus* in *Ectocyclops*. Neither by Claus nor by Sars was any type expressly designated. I have expressed the opinion (1928) that Claus's mention of *C. phaleratus* first in his final definition of *Paracyclops* might be accepted as establishing the type, and that, if this is so, we could allow *Ectocyclops* to sink into oblivion, as it deserves to do, retaining *Platycyclops* for *C. fimbriatus* and its allies. Kiefer (1928, p. 248) has objected that *C. affinis* was mentioned first by Claus in his preliminary designation of the genus, and appeals to the International Rules apparently to imply that he himself was the first to break up the genera, and has the right to determine their contents. While I am still of opinion that the correct and most satisfactory issue out of this tangle would be the solution I offered in 1928, I am prepared to submit, under protest, to Kiefer's scheme, as it is embodied in the 'Tierreich,' and we need uniformity rather than justice.

There is no reason to maintain *Heterocyclops*, Claus, for *C. affinis*, since there is no essential difference in the development of its antennule from that of *C. fimbriatus* (see p. 51).

Key to the British Species of Paracyclops.

1. Antennule of 8 segments . . . . (*C. fimbriatus*) 2.
   Antennule of 11 segments . . . . . . *C. affinis*.
2. Furcal rami 4–6 times as long as wide with short transverse row of spinules by lateral seta . . *C. fimbriatus* s. str.
   Rami 3–4 times as long as wide, with longitudinal dorsal row of spinules . . . . *C. f. poppei*.

Cyclops fimbriatus, Fischer.

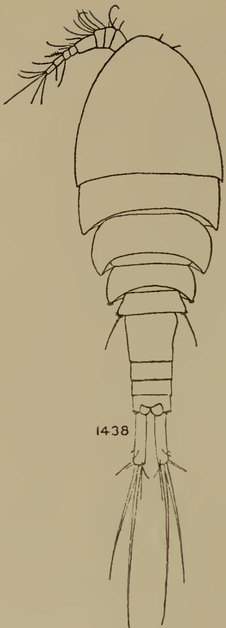
(Figs. 1438–1458.)

1853. *Cyclops fimbriatus*, Fischer, Bull. Soc. Moscou, XXVI, p. 94, figs.
1863. *C. crassicornis*, Sars, Forh. Vid. Selsk. Christ. 1862, p. 256.
1870. *C. gredleri*, Heller, Ber. Ver. Innsbruck, I, p. 47, figs.
1872. *C. pauper*, Frič, Arch. Landesdf. Böhmen, II, p. 233, figs.
1878. *C. crassicornis*, Brady, Mon. Brit. Cop. I, p. 118, figs.
1878. *C. magniceps*, Vernet, Bull. Soc. Vaud. XV, p. 532, figs.
1885. *C. margoi*, Daday, Monog. Eucopep. p. 264, figs.
1892. *C. fimbriatus*, Schmeil, Bibl. Zool. Heft XI, p. 161, figs.
1892. ,, Brady, Trans. N. H. Soc. Northd. XI, p. 90, figs.
1893. *Paracyclops fimbriatus*, Claus, Arb. Z. Inst. Wien, X, p. 348, figs.
1897. *C. bathybius*, Daday, Res. Erf. Balaton, II, p. 167, figs.
1912. *C. soli*, Kokubo, Annot. Zool. Japon, VIII, p. 102, figs.
1915. *Platycyclops fimbriatus*, Sars, Crust. Norway, VI, p. 81, figs.
1929. *Paracyclops fimbriatus* and *P. f. imminuta*, Kiefer, Z. wiss. Zool. CXXXIII, p. 47, figs.
1931. *C. f.* var. *anyschghtzara*, Schiklejew, Zool. Anz. XCIV, p. 188, figs.

Female.—Length ·86–·9 mm.

Body flattened, cephalothorax narrowed in front; th. som. 5 with lateral fringe of hairs. Genital somite broader than long; receptaculum with oval anterior part, and narrow, band-like posterior part. Abdominal somites with transverse rows of minute spinules. Furcal rami generally placed wide apart, slightly divergent, and generally slender, the length 4–6 times the width; lateral seta near end of ramus, with a few transversely arranged spinules in front of it; outer apical spine little more than half length of ramus, and a little shorter than inner seta; setæ 2 and 3 clothed with short stiff hairs, seta 3 nearly twice as long as seta 2. Antennule very short, of 8 segments, of which the 4th is conspicuously long; æsthete borne on seg. 5, longer than seg. 6; sensory hair on seg. 7 nearly as long as seg. 8. Many of the setæ are coarsely feathered. Antenna with last segment much shorter than seg. 3. Maxillule with palp distinctly 2-segmented. Maxilla short and stout, with 2 setæ on proximal lobe. Sars shows one only in this, and other, species of the subgenus; but there appear always to be two.* Maxillipede distinctly 4-segmented, the spines of segs. 3 and 4 short and stout. Legs with rami 3-segmented; spine formula

* See Lowndes, 1932D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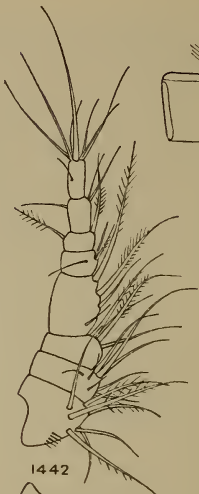
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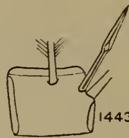
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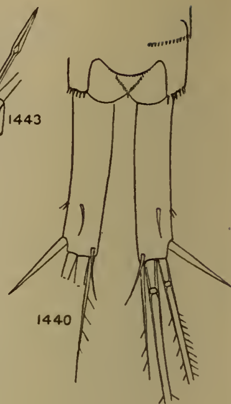
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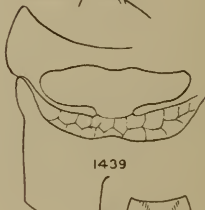
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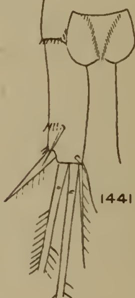
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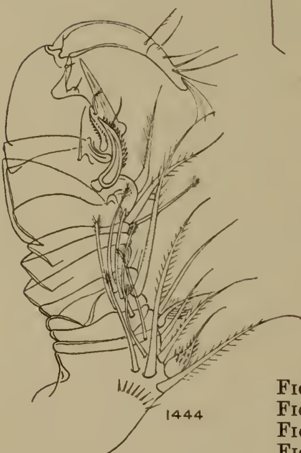
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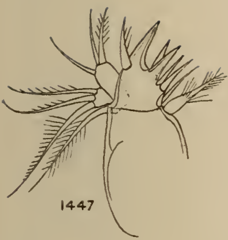
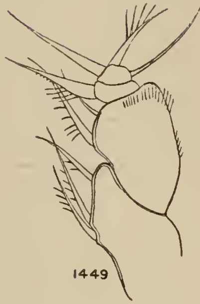
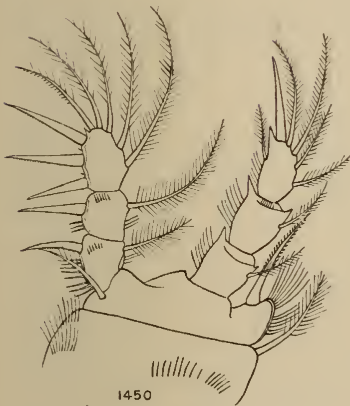
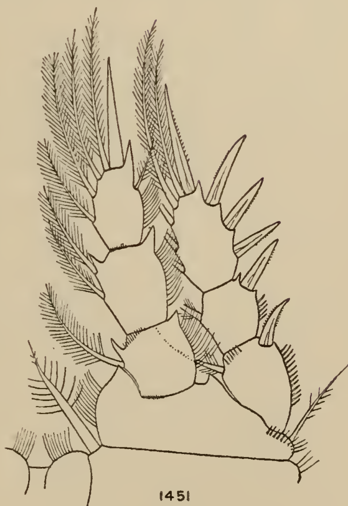
FIGS. 1438–1445.—*Cyclops fimbriatus.*

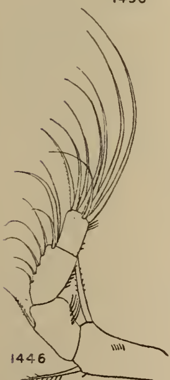
FIG. 1438.—Female, dorsal.
FIG. 1439.—Genital somite and receptaculum.
FIG. 1440.—Furcal rami, female.
FIG. 1441.—Furcal rami, male.
FIG. 1442.—Antennule, female.
FIG. 1443.—Seg. 5, showing æsthete.
FIG. 1444.—Antennule, male, ventral.
FIG. 1445.—Antennule, dorsal.











FIGS. 1446–1451.—*Cyclops fimbriatus.*

FIG. 1446.—Antenna.
FIG. 1447.—Maxillule.
FIG. 1448.—Maxilla.
FIG. 1449.—Maxillipede.
FIG. 1450.—Leg 1.
FIG. 1451.—Leg 2.

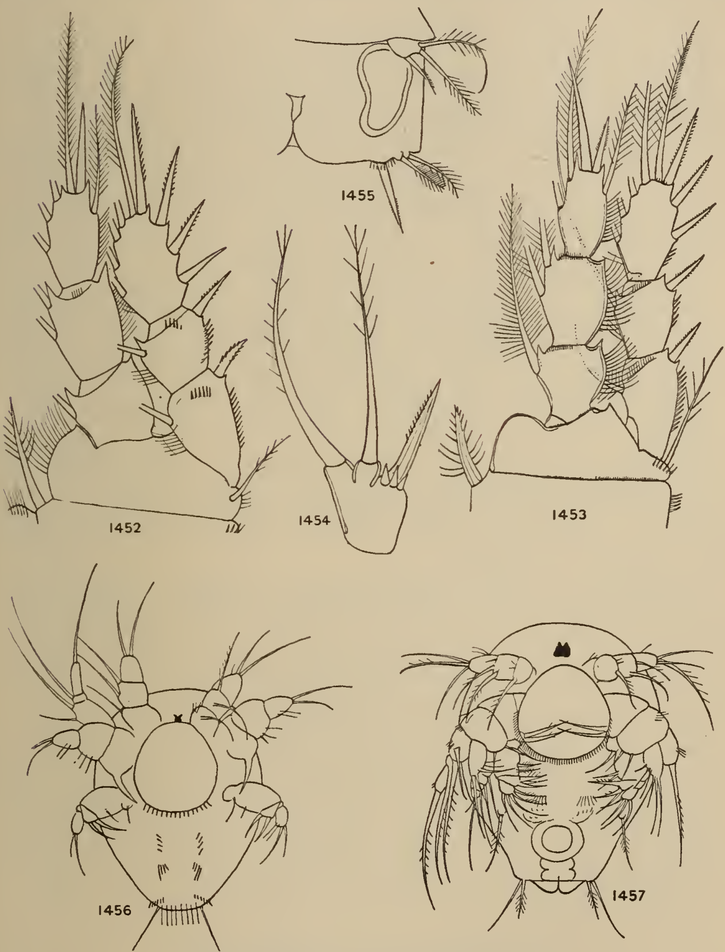
3.4.4.3. Leg 1 with very long inner spine on basis; outer spines of exopod very long; outer terminal seta of exopod with stiff hairs on outer side, and fine hairs on inner side (compare *Macrocyclops*). Legs 2–4 with fringe of spines on exopod segs. 1 and 2. Legs 2 and 3 the same, but outer spines of exopod stouter in leg 2. Leg 4: endopod 3 less than twice as long as wide (1·67–1·9 : 1); apical spines very unequal, the inner spine nearly, or quite, twice as long as the outer, and longer than the segment. Leg 5 unsegmented, with 2 setæ and a strong inner spine; the setæ generally equal, or the outer a little the longer.

Egg-sacs closely apposed to abdomen, with few large eggs.

Male.—Length ·74–·85 mm.

Furcal rami not so long and slender as in female, about 3 times as long as wide, and with distal transverse row of spinules more marked. The antennule consists, as usual, of 17 segments, but it is so shortened and compressed that it is most difficult to distinguish them; in fact it seems that segs. 4 and 5 are actually fused. Seg. 1 bears two long cylindrical æsthetes, and a peculiar modified seta, greatly swollen at its base, and covered, in this swollen part, with prickles. Eight æsthetes are distinguishable, of which one is on seg. 2, 4 are grouped closely together in the region corresponding to segs. 4–6, and one is on seg. 9. The number does not, therefore, correspond either with that found in *Macrocyclops* or in *Eucyclops*, but is nearest to the latter, and it is probable that there is also an æsthete on seg. 8 which I have not seen. Seg. 12 bears a huge curved spine with a double row of strong teeth. Seg. 13 has a spear-like spine. The distal part is short and flexed upon the middle part; 2 segments are distinguishable, the first bearing on its dorsal face a large blunt spine. Leg 6 with strong inner spine and 2 outer setæ, of which the inner is the shorter. Nauplius (Fig. 1456) very much flattened, pear-shaped. Labrum fringed with

hairs. A group of hairs on ventral side on either side, behind labrum. On dorsal side there is an oval area



FIGS. 1452-1457.—*Cyclops fimbriatus.*

FIG. 1452.—Leg 3.
FIG. 1453.—Leg 4.
FIG. 1454.—Leg 5.
FIG. 1455.—Legs 5 and 6, male.
FIG. 1456.—Nauplius I.
FIG. 1457.—Nauplius, stage II.

marked off, resembling the "nuchal organ" of Harpacticids. Antennules very short, the 2 setæ of seg. 2 springing quite close together. Exopod of antenna

apparently of 5 segments, the 3 middle segments, very small and together shorter than seg. 5.

Variation.

Kiefer (1928, 1929) has separated from within the old species *C. fimbriatus* the following new species :

P. abnobensis.—Furcal rami rather short, not quite 4 times as long as wide, but widely separated. Leg 4, inner apical spine twice as long as seg. 3. Outer seta of leg 5 very long.

Distribution.—Germany : Black Forest.

P. finitimus.—Furcal rami short, 3–3½ times as long as wide, close together. Apical seta 2 scarcely half length of seta 3. Setæ and spine of leg 5 about equal.

Distribution.—Morocco, South Africa, New Zealand.

He distinguished also a *forma imminuta* which differed only in the shorter furcal rami (length to width 4 : 1), and seems to be associated with an underground habitat (see Borutzky, 1930c).

Schiklejew's var. *anyschghtzara* (1931), from the Caucasus region, has an antennule of 10 segments, of which the last has a serrated hyaline membrane. Leg 5 is also quite different, according to his figure, and it seems this may be a distinct species.

Whether the two former are to be accepted as real species seems to be very doubtful. The differences are very small, and there is nothing known of their distribution or habitat which supports a distinction. The typical form varies very much in the form of the rami.

Distribution in Britain.

Apparently generally distributed, and not uncommon, throughout the British Isles.

Distribution Abroad.

Records of *C. fimbriatus* are very numerous, and point to a world-wide distribution ; but Kiefer holds that

more than one species is included in the name, and that therefore many of the records are unreliable. He himself has seen typical examples from Algeria, Madagascar, India and Paraguay, so that, whatever view be taken as to the status of his new species, the distribution of the typical form may be but little affected. The following list of records is for the species in its wider sense :

Europe : Generally distributed.

Asia : India (R. G.) ; Ceylon and Siam (Daday) ; Hawaii (Sars) ; Palestine (R. G.).

Africa : Algeria (Roy and Gauthier) ; Madagascar (Kiefer) ; Abyssinia (Lowndes) ; Zanzibar (Poppe and Mrázek) ; Natal (Brady) ; Canaries (Richard) ; Azores (Barrois).

America, North : Canada (Willey) ; United States (Marsh, etc.).

South : Argentine (Brian) ; Patagonia (Daday) ; Colombia (Thiébaud) ; Brazil (Van Douwe) ; Peru (Kiefer).

Australian region : New South Wales (Henry) ; New Zealand ? (Thomson) ; New Guinea (Daday).

Bionomics.

One of the most adaptable of species. It is able to live in the depths of lakes (down to 200 m.) ; in a thin film of water ; in running water ; underground ; or in mountains up to 2686 m. It is also recorded by Klie from inland salt-water pools, and by Richard similarly from saline water. There are a number of records of its occurrence in caves or springs, and I have found it in small pools in the Cheddar caves, without any other species. It is found, associated with *Bathynella*, in a quarry at Corsham (A. G. L.). Brehm, Graeter and others note its unusual faculty for living in flowing water. Schmeil drew attention to its power of creeping out of the water, pushing a film of water with it—a habit which it shares with *C. affinis* and *C. phaleratus* (see Scourfield, 1894, p. 18).

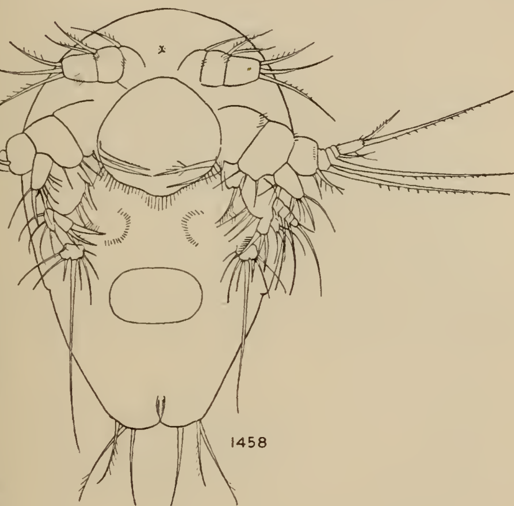
Cyclops fimbriatus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
1. Oxford, ♀	·83	410	143	5·4	73	65	314	..	98	1·8	205	128
2. ,, ♂	1·10	282	83	3·25	68	50	247	454	73	2·0	196	132
3. Corsham, ♀ (average)	·87	..	125	4·8	72	..	..	..	..	..	..	..
4. ,, ♂	·80	..	110	3·45	74	..	..	..	..	..	..	..
5. Cheddar Cave, ♀	·87	333	138	5·1	75	63	280	500	93	1·66	188	128
6. ,, ♂	·74	..	105	3·1	70	65	325	650	94	1·92	180	145
7. Salhouse, Norfolk, ♀	·95	357	126	6·0	73	68	272	480	73	2·14	176	133
8. India, ♀ (average).	·87	351	134	5·3	72	57	266	488	83	1·8	201	127
9. ,, ♂ ,,	·85	317	106	2·9	68	57	260	..	88	1·7	162	142
10. Delphi, Greece	·72	360	138	4·2	68	67	310	535	97	1·84	206	148
C. f. poppei : Cassiobury, ♀	·65	430	126	3·1	70	80	314	570	80	1·3	216	154

Cyclops fimbriatus poppei, Rehberg.
(Fig. 1459.)

1880. *C. poppei*, Rehberg, Abh. natur. Ver. Bremen, VI, p. 550, figs.
1892. *C. fimbriatus* var. *poppei*, Schmeil, Bibl. Zool. XI, p. 168, figs.
1909. *C. fimbriatus*, Marsh, Trans. Wisc. Acad. XVI, p. 1104, figs.
1929. *Paracyclops poppei*, Kiefer, Tierreich, Lief. LIII, p. 42.

As *P. fimbriatus*, but furcal rami close together and rather short (3 : 1). Dorsal spinules of rami continued



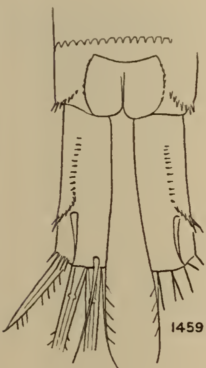


Fig. 1458.—*Cyclops fimbriatus*, nauplius, stage IV.
Fig. 1459.—*C. f. poppei*, furcal rami.

forwards in a line, reaching nearly to base of rami. Outer seta of leg 5 but little longer than median spine.

This form was regarded by Schmeil as merely a variety of *C. fimbriatus*, but is treated by Kiefer as a species. Though the differences in the form of the rami are not great, they appear to be constant, and without transitional forms. It is therefore easily recognized, and may, with advantage, be separated from *C. fimbriatus*. Whether it should be regarded as a species or subspecies is a matter of indifference.

Distribution in Britain.

I have not met with this form myself, and the following are all the records known to me :

Cassiobury Park, Herts; Hackney Marsh; Wanstead Park, Essex (D. J. S.).

Birmingham (A. G. L.).

Exeter Canal (D. J. S.).

Distribution Abroad.

Germany (Schmeil, Van Douwe, etc.).
Holland (Van Breemen, R. G.).
Switzerland (Graeter, Thiébaud).
Russia (Rylov).
South Africa (Sars).
North America (Marsh, etc.).

Kiefer notes that all records of *P. fimbriatus* from North America seem to refer actually to *P. f. poppei.*

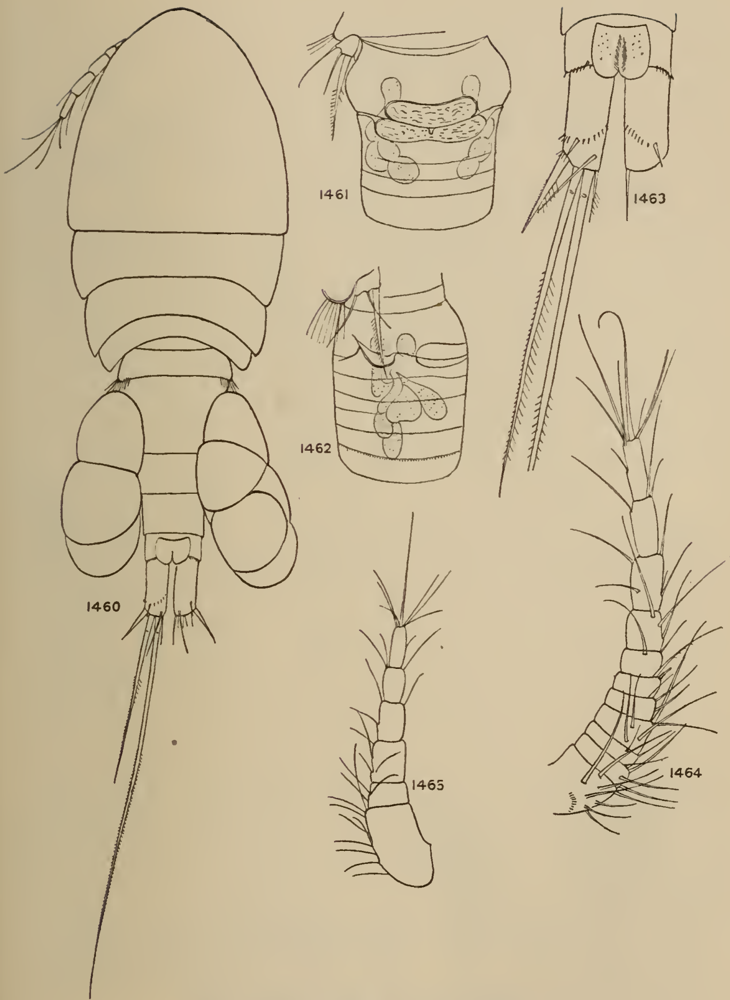
Cyclops affinis, Sars.

(Figs. 1460–1478.)

1863. *Cyclops affinis*, Sars, Forh. Vid. Selsk. Christ. 1862, p. 256.
1878. ,, ,, Brady, Mon. Brit. Cop. I, p. 112, figs.
1880. *C. pygmæus*, Rehberg, Abh. Ver. Bremen, VI, p. 546, figs.
1892. *C. affinis*, Schmeil, Bibl. Zool. Heft XI, p. 157, figs.
1892. ,, Brady, Trans. N. H. Soc. Northd. XI, p. 112, figs.
1893. *Paracyclops affinis*, Claus, Anz. Ak. Wien, no. 9, p. 83.
1893. *Heterocyclops affinis*, Claus, Arb. Zool. Inst. Wien, X, p. 348.
1901. *C. affinis*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 98, figs.
1915. *Platycyclops affinis*, Sars, Crust. Norway, VI, p. 80, figs.
1929. *Paracyclops affinis*, Kiefer, Tierreich, Lief. LIII, p. 42.
1932. *Platycyclops affinis*, Lowndes, Ann. Mag. Nat. Hist. (10), X, p. 395, figs.

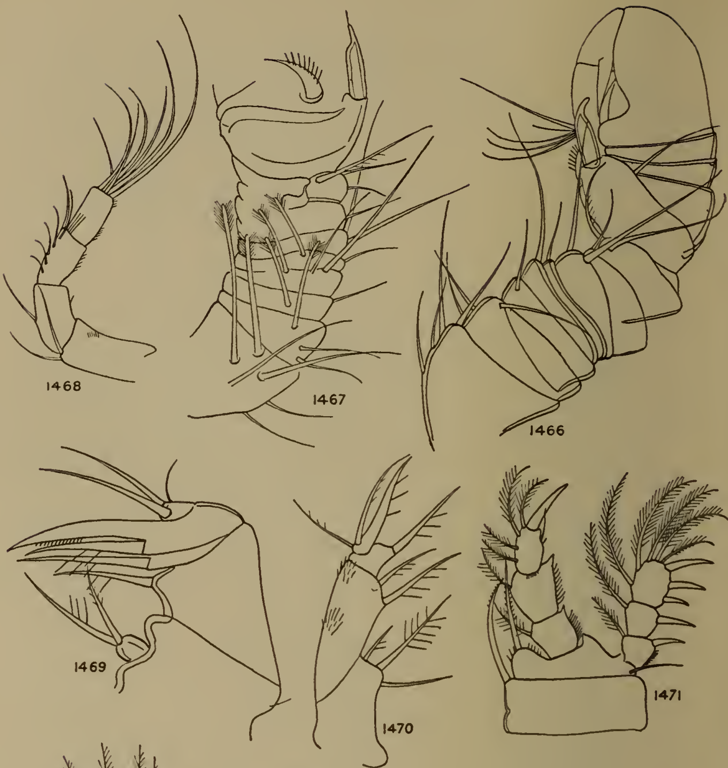
Female.—Length ·72 mm.

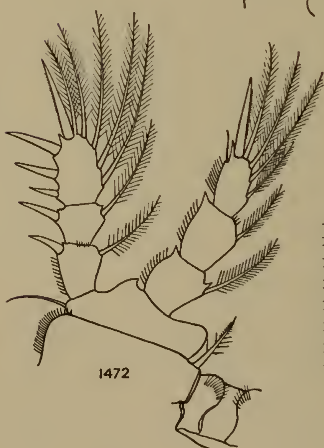
Body scarcely flattened. Th. som. 5 with rounded angles clothed with long stiff hairs. Genital somite broader than long ; receptaculum with anterior portion slightly concave in front, posterior part a narrow transverse band. Abdominal somites with margins not



FIGS. 1460–1465.—*Cyclops affinis.*

FIG. 1460.—Female, dorsal.
FIG. 1461.—Genital somite, ventral.
FIG. 1462.—Genital somite, lateral, showing glandular structures.
FIG. 1463.—Furcal rami, dorsal.
FIG. 1464.—Antennule, female.
FIG. 1465.—Antennule, female, copepodid V.





Figs. 1466–1472.—*Cyclops affinis.*

Fig. 1466.—Antennule, male, dorsal.
Fig. 1467.—Antennule, male, ventral.
Fig. 1468.—Antenna.
Fig. 1469.—Maxilla.
Fig. 1470.—Maxillipede.
Fig. 1471.—Leg 1.
Fig. 1472.—Leg 2.

serrated, marked, except the last somite, with transverse ridges. Anal incision with marginal hairs, and surface of anal depression with small spinules. Furcal rami 2–2½ times as long as wide, with an obliquely transverse row of small spines on dorsal face running from insertion of lateral seta ; lateral seta very small and inserted on dorsal face ; inner apical seta very small, about two-thirds as long as outer spine ; seta 3 about twice as long as seta 2, with short marginal prickles ; seta 2 with prickles along outer side and hairs on inner side.* Antennule very much shorter than cephalothorax, of 11 segments ; segs. 1–6 very short ; seg. 9 with æsthete. According to Schmeil seg. 7 corresponds to segs. 7 and 8 of the normal 12-segmented antennule, while in other species with 11 segments it is seg. 3 which is undivided. The following table shows Schmeil's view as to homologies of segments :

C. serrulatus .	1	2	3	4	5	6	7	8	9	10	11	12
C. affinis .	1	2	3	4	5	6	7		8	9	10	11
C. phaleratus .	1	2	3		4	5	6		7	8	9	10
C. bicolor .	1	2	3		4	5	6	7	8	9	10	11

Schmeil regards the antennule of *C. affinis* as derived from the *serrulatus*-form. Claus (1893, p. 32) points out that *C. affinis* is unique in having 4 (instead of 5) segments in the antennule of the first copepodid. He considered that Schmeil's view is wrong and that the correspondence of segments is as shown, thus :

C. serrulatus .	1	2	3	4	5	6	7	8	9	10	11	12
C. affinis .	1	2	3	4	5	6	7	8	9		10	11
Microcyclops .	1	2	3		4	5	6	7	8	9	10	11

* Graeter (1899) figures an abnormal pair of furcal rami in which only one of the two middle setæ is present.

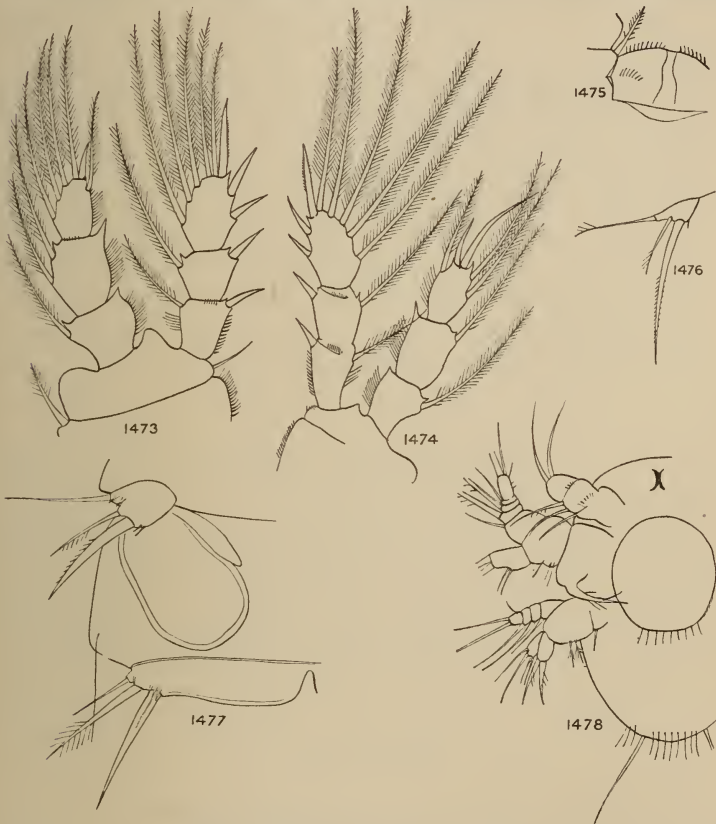
He considered the 4-segmented copepodid stage must come about by suppression of the division of seg. 9 of the adult (or last but two), which occurs in all other species at the 5-segmented stage. For this reason he separated *C. affinis* in a new sub-genus *Heterocyclops* (see p. 51). Antenna: seg. 4 as long as seg. 3; setæ of seg. 1 comparatively short. Maxilla with rounded basal lobe bearing two setæ. Maxillipede resembling that of *P. phaleratus*, the terminal segment not distinguishable, but apparently fused with the basal part of the strong spine borne by it. Legs with rami 3-segmented; spine formula either 3.4.3.3 or 3.3.3.3. My own specimens have the former, and the same is given by Vosseler and Rehberg, but Schmeil gives the latter. Leg 1 with unusually long stout spines on coxa and basis; endopod 3 with very short inner setæ,* and terminal spine remarkably stout. Coxa of legs 2–4 with outer fringe of stiff hairs. Leg 2: endopod 2 with 1 seta; outer seta of endopod 3 very short, very much shorter than the apical spine, which is much longer than in leg. 3. Sars's figure of leg 2 is actually of leg 3 (Lowndes, 1932D). Leg 3: endopod 2 with 2 setæ; apical spine of endopod very short. Leg 4 with uniting lamella convex, with marginal row of spinules; endopod 3 less than twice as long as wide; apical spines very unequal, the inner about twice as long as outer, and bent inwards; seg. 2 with 1 inner seta only. Leg 5 a small quadrangular plate bearing a long inner spine and a short slender middle seta; the outer seta borne on a lateral papilliform projection. Egg-sacs rather small, closely pressed to abdomen, and with few, rather large eggs.

Male.—Length ·56 mm.

Antennule short and stout; proximal part with 6 long sense-cylinders, feathered at end. I have not been able to see the two distal æsthetes figured by Schmeil. Middle part very short and thick; seg. 9

* Lowndes (1932D) finds these setæ of equal length, as shown also by Sars.

bearing a peculiar inner spine constricted at end, this constricted part bent inwards slightly and with a delicate terminal hair; seg. 10 with a strong pectinate spine. Terminal part consisting of 2 segments, the first bearing



FIGS. 1473–1478.—*Cyclops affinis.*

FIG. 1473.—Leg 3.
FIG. 1474.—Leg 4.
FIG. 1475.—Leg 4, uniting lamella.
FIG. 1476.—Leg 5.
FIG. 1477.—Legs 5 and 6, male.
FIG. 1478.—Nauplius, stage I.

a strong inner spine. Leg 5 as in female, but inner spine not much longer than middle seta. Leg 6 with long inner spine and 2 setæ, the inner of which is very stout, and nearly as long as inner spine; outer seta much shorter.

Distribution in Britain.

Scotland: Several records, from Shetlands southwards (Scott); Skye (A. G. L.).

Wales: Llyn Padarn, Anglesey (D. J. S.); Pwllheli (Brady).

Ireland: Monaghan (Popple); Clare Island (D. J. S.).

Lake District (Pratt).

Northumberland (Brady).

Essex (D. J. S.).

Norfolk: 14 localities (R. G.).

Wiltshire (A. G. L.).

Oxford and Berkshire (R. G.).

Cambridgeshire: Wicken Fen (A. G. L.).

Isle of Man (D. J. S.).

Probably generally distributed.

Distribution Abroad.

Europe: Generally distributed.

Asia: China (Sars); Turkestan (Daday); Manchuria (Rylov); India (R. G.); Mesopotamia (R. G.).

Africa: Algeria (Roy and Gauthier); Madagascar (Kiefer); Abyssinia (Lowndes); Egypt (Chappuis).

Australian region: New South Wales (Sars, Henry).

Bionomics.

This is a creeping form, found among weeds. I have taken it myself most commonly in decayed stems of *Typha* and *Scirpus*. I have not found it myself before April, but Lowndes notes abundance of females, males being very rare, in January and February. He describes peculiar bodies in the genital somite having the appearance of eggs. The ovaries, at the time, were empty, and he concluded that these bodies might be resting eggs. Breeding experiments did not confirm this supposition.

Subgenus **ECTOCYCLOPS**, Brady.

1904. Brady, Proc. Zool. Soc. Lond. II, p. 124.
1914. *Platycyclops* (part), Sars, Crust. Norway, VI, p. 76.
1927. Kiefer, Zool. Anz. LXXIII, p. 304.
1929. Kiefer, Tierreich, Lief. LIII, p. 40.

Body flattened, without marked constriction between thorax and abdomen. Furcal rami broad, with dorsal transverse rows of spinules. Antennule short, of 10 or less segments. Leg 1 endopod 1 with 1 seta. Leg 5 completely fused with th. som. 5, with 3 spines or setæ. Ovary reaching into abdomen.

Type.—*C. phaleratus*, Koch.

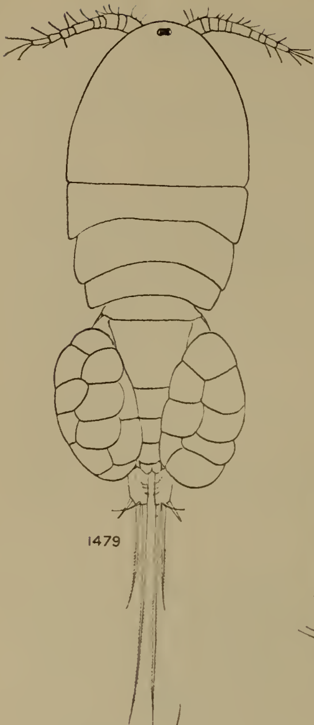
Cyclops phaleratus, Koch.

(Figs. 1479–1501.)

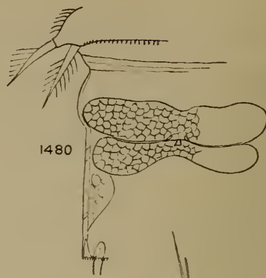
1838. *C. phaleratus*, Koch, Deutschl. Crust. Fasc. XXI, no. 9.
1851. *C. canthocarpoides*, Fischer, Bull. Soc. Moscou, XXIV, 2, p. 426, figs.
1874. *C. fischeri*, Poggenpol, Schr. Fr. Naturw. Mosc. X, p. 73, figs.
1880. *C. phaleratus*, Brady, Mon. Brit. Cop. I, p. 116, figs.
1882. *C. adolescens*, Herrick, Rep. Geol. Surv. Minn. X, p. 231, figs.
1883. *C. perarmatus*, Cragin, Trans. Kansas Ac. VIII, p. 72, figs.
1892. *C. phaleratus*, Schmeil, Bibl. Zool. Heft XI, p. 170, figs.
1892. ,, Brady, Trans. N. H. Soc. Northd. XI, p. 90, figs.
1893. *Paracyclops phaleratus*, Claus, Arb. Z. Inst. Wien, X, p. 348.
1904. *Ectocyclops rubescens*, Brady, Proc. Zool. Soc. p. 124, figs.
1912. *C. p. japonicus*, Kokubo, Annot. Zool. Japon. VIII, p. 103, figs.
1913. *C. quinquepartitus*, Marsh, Smiths. Coll. LXI, p. 17, figs.
1914. *Platycyclops phaleratus*, Sars, Crust. Norway, VI, p. 78, figs.
1927. *C. phaleroides*, Labbé, Arch. Zool. Exp. LXVI, p. 198, figs.
1930. *E. medius*, Kiefer, Zool. Anz. LXXXVII, p. 318, fig.

Female.—Length ·9–1·0 mm.

Thorax flattened, greatest width about middle, and rather more than one-third of total length. Th. som. 5 with transverse rows of denticles on posterior ventral margin broken in middle; lateral margins with short scattered hairs. Genital somite wider than long; receptaculum extending right across somite; posterior part very narrow, deeply indented in middle. Abdominal somites with hyaline membrane finely toothed. Furcal rami about twice as long as wide,



1479



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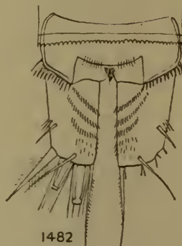
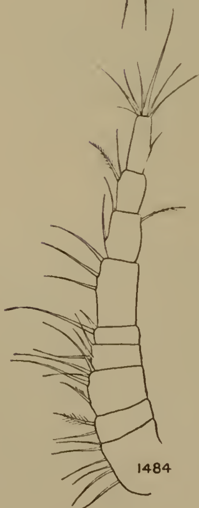


1482



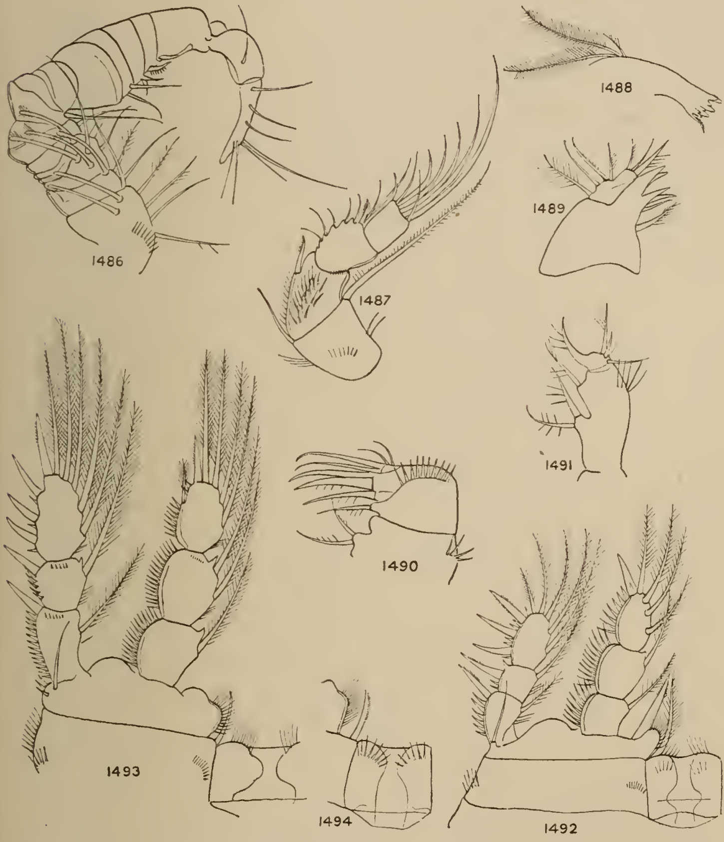
1484

1485

Figs. 1479–1501.—*Cyclops phaleratus.*

Fig. 1479.—Female, dorsal.
Fig. 1480.—Genital somite and receptaculum.
Fig. 1481.—Furcal ramus, female. Mesopotamia.
Fig. 1482.—Furcal rami, male.
Fig. 1483.—Antennule, female.
Fig. 1484.—Antennule of 9 segments.
Fig. 1485.—Antennule, female. Abyssinia. (*C. rubescens.*)

parallel, with 3 transverse rows of small spinules on inner side ; lateral seta very small, inserted on dorsal face ; inner apical seta very short, variable, sometimes



FIGS. 1486--1494.—*Cyclops phaleratus.*

FIG. 1486.—Antennule, male.
FIG. 1487.—Antenna.
FIG. 1488.—Mandible.
FIG. 1489.—Maxillule.
FIG. 1490.—Maxilla.
FIG. 1491.—Maxillipede.
FIG. 1492.—Leg 1.
FIG. 1493.—Leg 3.
FIG. 1494.—Leg 3, uniting lamella.

longer or sometimes shorter than outer spine ; setæ 2 and 3 sometimes stiff and spine-like ; seta 3 nearly or quite twice as long as seta 2, denticulate along margins ;

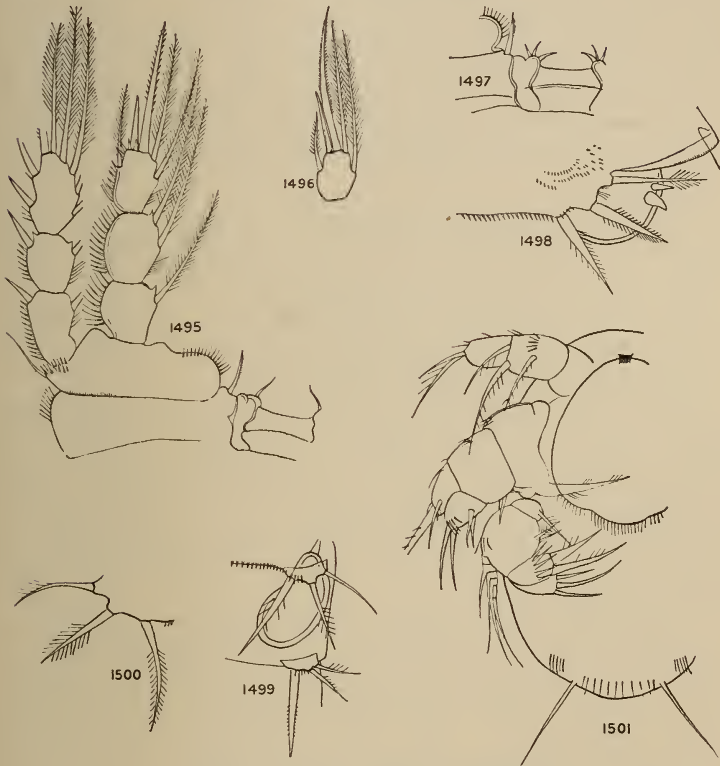
seta 2 with denticles on outer margin and hairs along inner side. Schmeil notes that a parasitic Acinetan is commonly found in the anal cleft, which has been mistaken by Claus for a structure belonging to the *Cyclops* itself. Antennule shorter than th. som. 1, usually of 10 segments; rarely seg. 6 is divided into 2, while segs. 7 and 8 may be united, leaving 9 segments (Fig. 1484). Antennæ very short and stout; segs. 2 and 3 each with a spine at distal angle, which is curved at end and bears a comb of very delicate hairs. Schmeil suggests that these are sensory organs. Seg. 3 with margin notched. Maxilla very short and compressed, with transverse row of spines across face of seg. 2; proximal lobe with 2 setæ. Maxillipede with endopod reduced to a single small segment, bearing a strong curved inner spine and 3 setæ. Legs with coxa and basis very broad, and the rami set wide apart; spine formula 3.4.4.3. Leg 1 with an exceedingly strong inner coxal spine; outer margin of exopod armed with strong spinules. Leg 4 with uniting lamella smooth except for a curved seta springing from each side of margin; in a specimen from Mesopotamia there are 3 such setæ. Endopod 3 about $1\frac{1}{2}$ times as long as wide; outer seta short; apical spines very unequal, the inner more than twice as long as outer, and about twice as long as seg. 3. Leg 5 consisting of a broad plate united with th. som. 5, and bearing 2 strong spines and an outer seta, all of about the same length, and much shorter than genital somite. Schmeil states that outer seta is smooth, but I find it always feathered. Egg-sacs closely pressed to abdomen. Ovaries extending nearly to end of abdomen.

Colour: Legs, part of thorax, and end of abdomen and antennules, blue. General colour of body light brown.

Male.—Length ·73–·75 mm.

Antennule of 17 segments, bearing long cylindrical æsthetes. Leg 5 with very long inner spine and 2

nearly equal setæ. Leg 6 very well developed, resembling leg 5, with inner spine very long and stout, and 2 outer setæ of about equal length.



Figs. 1495–1501.—*Cyclops phaleratus.*

Fig. 1495.—Leg 4.
Fig. 1496.—Leg 4, endopod 3. Abyssinia.
Fig. 1497.—Leg 4, uniting lamella. Mesopotamia.
Fig. 1498.—Leg 5.
Fig. 1499.—Legs 5 and 6, male.
Fig. 1500.—Leg 5. Abyssinia (*C. rubescens*).
Fig. 1501.—Nauplius.

Variation.

Lowndes (1931) has re-described *Ectocyclops rubescens*, Brady, from Abyssinian specimens, and regards it as a distinct species, though Kiefer treats it as a synonym

of *C. phaleratus*. The differences on which he lays stress are : (1) Relative lengths of segments of antennule. Apparently in *C. rubescens* seg. 6 is divided into two ; but this is sometimes also the case in *C. phaleratus*. In *C. rubescens* segs. 7 and 8 are united (so that the antennule remains of 10 segments). This union of segs. 7 and 8 may also occur in *C. phaleratus* (Fig. 1484). In a specimen of *C. phaleratus* from Mesopotamia, the antennule is of 11 segments by division of seg. 6, as in *C. rubescens*.

(2) Relative length of spines on leg 5. The only difference consists in the greater length of the inner spine.

(3) Relative length of spines in leg 1. I am unable to find any appreciable difference here.

(4) Smaller size and slenderer shape.

These differences are, in the aggregate, much greater than those which Kiefer commonly accepts as distinguishing species (*e.g. E. medius*, Kiefer) ; but, knowing as we do nothing whatever as to the limits of variation of the European form, it seems better to regard *C. rubescens* as, at most, an African subspecies of *C. phaleratus*.

Kiefer (1930c) has added two more to the three species included in the genus in his work of 1929—*E. medius*, Kiefer, from India and Africa, and *E. hirsutus*, Kiefer, from Madagascar. The former differs only from *E. phaleratus* in having the outer seta of leg 5 longer, as it is in males of British species. *E. hirsutus* differs from *E. phaleratus* in the form of the rami, and is said to resemble *E. compactus*, Sars.

Distribution in Britain.

This is a rather rare species, found singly or in small numbers in varied conditions.

Scotland : Several localities in lowlands (Scott).

Lake District (Pratt, D. J. S.).

Birmingham (A. G. L.).

Cyclops affinis *and* phaleratus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of segment 3.
C. affinis :												
1. Sutton, Norfolk	·72	360	97	2·55	..	72	290	650	55	1·7	230	170
2. ,, ,,	·8	287	78	2·23	73	62	237	510	42	1·74	195	184
3. ,, ,, ♂	·56	360	88	2·24	..	80	305	715	57	..	..	..
4. Ringmere, Norfolk	·73	355	89	2·0	..	71	280	600	41	1·79	220	170
5. Oxford	·85	305	64	2·3	68	52	247	500	42	1·74	205	174
6. Isle of Wight	·72	360	96	2·4	75	72	265	630	52	1·46	218	184
7. Abyssinia	·57	350	105	2·6	..	86	297	610	68	1·45	200	188
C. phaleratus :												
1. East Ruston, Norfolk	·98	385	82	1·96	..	59	280	..	35	1·56	125	220
2. ,, ,,	·90	400	88	2·0	..	61	300	710	67	..	..	..
3. ,, ,, ♂	·74	390	88	2·1	..	64	325	770	55	1·75	121	190
4. Sutton, Norfolk	·95	410	82	1·85	60	63	229	450	63	1·5	237	237
C. rubescens :												
Abyssinia	·86	380	82	1·79	..	70	320	640	70	1·43	245	270

Essex (D. J. S.).
Norfolk : From 18 localities (R. G.).
Ireland (Popple).
Anglesey, Isle of Man (D. J. S.).
Wiltshire : Tisbury (D. J. S.).
Cambridgeshire : Wicken Fen (A. G. L.).

Distribution Abroad.

Europe : Generally distributed.

Asia : Palestine (Krampner, R. G.) ; Ceylon, Sumatra (Daday) ; India (R. G.) ; Japan (Kokubo) ; Central Asia (v. Douwe) ; Manchuria (Rylov).

Africa : Madagascar (Kiefer) ; East Africa (Daday) ; Egypt (R. G.) ; Camerun (Kiefer) ; South Africa (Sars, Brady) ; Abyssinia (Lowndes).

America—North : Canada (Willey) ; United States (Marsh, etc.) ;

South : Argentine (Pesta) ; Paraguay (Daday) ; Brazil (v. Douwe) ; Colombia (Thiébaud) ; Venezuela (Pearse).

Australian region : New South Wales (Sars, Henry) ; New Guinea (Daday).

BIFIDA, Graeter.

1903. A. Graeter, Rev. Suisse Zool. XI, p. 462.
1927. *Cyclopinæ*, Kiefer, Zool. Anz. LXXIII, p. 304.
1929. ,, Kiefer, Tierreich, Lief. LIII, p. 45.

Th. som. 5, with rare exceptions, without fringe of hairs. Male antennule with club-shaped æsthetes in addition to normal complement of setæ ; leg 5 2-segmented or with seg. 1 more or less fused with th. som. 5, the seta of seg. 1 then springing from the somite ; seg. 2 with 2 apical setæ, or with apical seta and inner seta or spine, which may be lateral or near apex ; this inner spine occasionally absent. Nauplius with exopod of antenna composed of 5–7 segments of about equal length.

Graeter divided the Bifida into two sections, Chætophora (*leuckarti–oithonoides* group) and Acanthophora. His views as to the relation of the species in the latter group differ considerably from that of Schmeil. Kiefer, in extending and amending Graeter's system, has eliminated certain errors, and has returned almost exactly to Schmeil's grouping of the species. In place of Schmeil's 5 groups Kiefer makes 8 genera or subgenera, in addition to 3 genera—*Bryocyclops*, *Orthocyclops* and *Allocyclops* (1932)—for species not known or dealt with by Schmeil. That these groups do, in fact, correctly express the relationships of the species is most probable; but it is doubtful if there is any practical advantage in treating them as genera or subgenera. Apart from the expression of one's conception of phylogeny, a generic or subgeneric grouping is intended to be of practical convenience, making it possible, in naming a species, to exclude from consideration all but a comparatively small number of species. This can only be done if the groups are unambiguously defined. But if this criterion is applied to Kiefer's subgenera, it is evident that no sharp distinction is possible. For instance the distinctions between *Microcyclops* and *Metacyclops*, and between *Acanthocyclops* and *Diacyclops*, consist in minute differences between the position and size of the lateral spine on leg 5 which it is impossible to define without ambiguity. The three groups *Megacyclops*, *Acanthocyclops* and *Diacyclops* are so intimately bound together that, even if one may admit that they may be diverging phyletic lines, there is no practical means of separating them. One may refer, in evidence, to the confusion which has reigned in American literature between the species *C. viridis* and *C. vernalis*, which, according to Kiefer, are types of different subgenera.

There seems to be no reasonable hope of arriving at any satisfactory phyletic system for the many *Cyclops* with reduced segmentation of the legs, such as *C. minutus*, *C. gracilis*, *C. varicans* and their allies. Kiefer,

in 1928, regarded *C. minutus* as an offshoot of the *bicuspidatus* group, within his subgenus *Diacyclops*, while *C. gracilis* was referred to *Mesocyclops*, subgenus *Metacyclops*. The remainder (*varicans–bicolor* group) he regarded as most uncertain, but included them in *Diacyclops*. In his final system (1929) he adopts Claus's *Microcyclops* for the *varicans*-group, but refers *gracilis* and *minutus* to *Metacyclops*, transferring this subgenus from *Mesocyclops* to *Cyclops*.

In my opinion the whole group of *Cyclops* is too ancient, and too homogeneous, to permit of subdivision beyond a certain point. While some groups of allied species are sufficiently obvious, there must always remain a proportion whose relationship is entirely obscure. In the case of the "*Microcyclops*" forms there are evidently several distinct lines of evolution, but it is by no means clear from what point they start, or at what point they end. It may probably be conceded that all the species included by Kiefer in *Microcyclops* are closely related, and it is most probable that they are derived from the *vernalis*-series; but it is not at all certain that his genus *Metacyclops* is a natural assemblage of species. There seem to be three separate lines of evolution within it, thus :

1.	2.	3.
minutus-group.	*dengizicus*-group.	*gracilis*-group.
planus.	*dengizicus*.	*gracilis*.
arnaudi.	*panamensis*.	*mendocinus*.
monacanthus.		*leptopus*.
necessarius.		

On the other hand, such groups cannot be clearly defined, and it is impossible to say to what other groups they are related, or whether they are so intimately allied to each other as to require to be united in one subgenus.

A number of peculiar forms, generally of subterranean origin, have been recently described, of which *C. unisetiger* is an example, which are placed by Kiefer in

his subgenus *Diacyclops*; but it is almost impossible to frame any definition which will exclude them, as a whole, from *Microcyclops*. Their relationship is most obscure, and nothing is lost by including them in *Microcyclops*, which is already somewhat of a dumping-ground for unclassifiable species.

In these circumstances it is most difficult to decide upon a course of action. There is no difficulty in accepting Graeter's primary division into Chætophora (= *Mesocyclops*) and Acanthophora (*Cyclops* and *Microcyclops* of Kiefer); but it does not seem possible to divide the latter into clearly definable subgeneric groups. Although Kiefer has established 6 such groups, the definitions so far overlap that he has only to a very limited extent been able to make any distinction between the subgenera in his key to the species. In my opinion it is only practicable to separate three groups:

1. *Cyclops* s. str.
2. *Megacyclops*, *Acanthocyclops*, *Diacyclops* (the *bicuspidatus*-group of Schmeil).
3. *Microcyclops*.

Even so it is impossible to make such a clear-cut distinction as one would wish, owing to the existence of the aberrant subterranean forms. Again, if this course is adopted, it is difficult to know what name can be applied to Group 2, since it is unsatisfactory to adopt either of Kiefer's names in a very much wider sense than he intended; but the only alternative is to introduce a new name, which is also objectionable when there are so many already.

Subgenus **CYCLOPS** s. str.

1929. *Cyclops* s. str. Kiefer, Tierreich, LIII, p. 49.

Furcal rami with inner margin hairy and with longitudinal dorsal ridge; antennules of 17 segments; segs. 15–17 with lateral row of minute spinules; exopodite

3 of legs 1–4 with 5 setæ ; leg 5 2-segmented, seg. 2 with large spine in middle of inner side.

Type.—*C. strenuus*, Fischer.

Key to the Species of Subgenus Cyclops s. str.

1. Antennule of 14 segments . . . . *C. insignis.*
   Antennule of 17 segments . . . . . . 2.
2. Leg formula 2.3.3.3 . . . . 3.
   Leg formula 3.4.3.3 . . . . 5.
3. Th. soms. 4 and 5 much expanded, pointed . *C. vicinus.*
   These somites not expanded . . . . . . 4.
4. Furcal rami about 8 times as long as wide. Inner apical seta not much longer than outer . . *C. furcifer.*
   Rami 4–5 times as long as wide ; inner apical seta nearly twice as long as outer . . . . *C. kolensis.*
5. Th. soms. 4 and 5 expanded, pointed . . *C. scutifer.*
   These somites not expanded . . . . . . 6.
6. Rami 8 times as long as wide ; inner and outer apical setæ nearly equal . . . . . . *C. furcifer.*
   Rami rarely 8 times as long as wide ; inner apical seta nearly twice as long as outer . . (*C. strenuus.*) 7.
7. Leg 4 endopod 3 less than 3 times as long as wide ; furcal seta 4 usually shorter than ramus . *C. strenuus* s. str.
   Leg 4 endopod 3, 3 times as long as wide ; seta 4 longer than ramus . . . . 8.
8. Somite of leg 2 produced backwards on either side as a rounded lobe . . . . . . *C. s. tatricus.*
   This somite not so produced . . . *C. s. abyssorum.*

Group of *Cyclops strenuus.*

The typical *C. strenuus*, Fischer, is the central form of a group of *Cyclops* which is quite clearly circumscribed, though the relationship of the members of it is most obscure. Several forms have received names as distinct species from Sars, Claus and others, but Schmeil, after careful consideration of published descriptions, and examination of specimens from various sources, came to the conclusion that two only, *C. strenuus* and *C. insignis*, Claus,* could be maintained. About the

* *C. insignis* has not been seen in Britain. Brady's *C. insignis* is *C. bicuspidatus lubbocki.*

distinctness of the latter there has never been any question ; but to what extent *C. strenuus*, Schmeil, is a variable species or a composite of several is by no means agreed. The following tabular statement will show how much opinions have differed.

Schmeil, 1892.	Lilljeborg, 1902.	Sars, 1913.	Kozminski, 1927.	Kiefer, 1929.
		strenuus		*strenuus.*
	strenuus	*abyssorum*	*strenuus*	*abyssorum.*
		lacustris	.	*lacustris.*
	kolensis	(*-strenuus*)		(*-strenuus*).
strenuus	*miniatus*	..	*strenuus*	*furcifer.*
			f. *furcifer*	
	scutifer	*scutifer*	*scutifer*	*scutifer.*
	vicinus	*vicinus*	*vicinus*	*vicinus.*

Although literature abounds in references to, and descriptions of, the species "*C. strenuus*," the only serious attempts to come to any soundly-based conclusion as to the relationship of the various forms are those of Kozminski (1927) and Rzoska (1931), who have applied statistical methods to a large material, though from a limited area. Kozminski came to the conclusion that three species could be distinguished—*C. strenuus*, Fischer, *C. scutifer*, Sars, and *C. vicinus*, Uljanin—each of which includes two or more "forms." It will be seen from the table that his results are not accepted by Kiefer (1929). Rzoska fully confirmed Kozminski's conclusion, but with the addition of *C. kolensis*, Lillj., as a distinguishable species.

Kozminski later (1932) raised his *C. strenuus* f. *tatricus* to the rank of a separate species.

It may not be too much to say that the whole question of the status of these forms is still open. Statistical inquiry on Kozminski's lines is necessary, though it is open to serious objection, and is likely in itself to lead to no final conclusion. Most of the "Indices" used by Kozminski and Rzoska are measurements of contractile parts, or are reduced to comparison with total

length, which itself depends largely on degree of contraction of somites. Such a standard for comparison cannot be avoided, but it seriously reduces the value of the figures obtained. Such figures cannot replace morphological description and accurate drawings. The final decision is for the future, and must rest upon experimental breeding. Schmeil's conclusion is certainly not acceptable to-day. For him the identity in structure of leg 5 and receptaculum were conclusive; but it is necessary to take other details into account, and, if constant differences in these characters can be established, small though they may be, distinct species or races must be admitted, especially if they can be shown to be associated with distinct ecological preferences.

In forming an opinion as to which of these to accept, published information, with the exception of that of Kozminski and Rzoska, is not of much help, and I do not propose to give the space necessary for a discussion of all previous work. I am in agreement with Kozminski and others in separating *C. vicinus* and *C. scutifer* as distinct species from the tangle of related forms. The latter is not known to occur in Britain, but I have examined Swedish specimens and am satisfied that it is easily recognizable. A description and figures of it are given for comparison with the British forms. There remain in doubt the "species" *strenuus*, *lacustris*, Sars, *furcifer*, Claus (= *miniatus*, Lillj.), *kolensis*, Lillj., and *tatricus*, Kozm. Of these *C. lacustris* is not known to occur in this country, and I have not seen specimens. It is regarded by Kozminski as a limnetic variety of *C. strenuus*, apparently with good reason. Of *C. furcifer* and *C. tatricus* I have examined specimens from several localities. Sars relies, in distinguishing the species with which he deals, upon the form of thoracic soms. 4 and 5 and the relative length of the furcal rami. All these forms have these somites little expanded, and so differ as a whole from *C. vicinus* and *C. scutifer*, but the shape of these somites is very

variable, and so also is the length of the rami, so that it is impossible on these characters alone to distinguish species. It is necessary to take into account also the measurements of the furcal setæ and of exopod 3 of leg 4 with its terminal spines. Such measurements are given here. Taking all these characters into consideration it seems that *C. miniatus* is a fairly stable form which, though not easily separated from certain varieties of *C. strenuus*, may with convenience be regarded as a distinct species. This conclusion is strongly supported by Mr. Lowndes's breeding experiments. On the other hand, *C. strenuus* is a species so variable and adaptable that scarcely any two colonies are exactly alike, and no real distinction can be drawn between it and *C. abyssorum*. In this country the latter can, however, be recognized by certain small features, and appears to have a definite geographical limitation. It is therefore recognized here as a subspecies of *C. strenuus*.

C. tatricus is a form which seems to be geographically localized and easily recognizable by its form of body, but whether it should be treated as a subspecies of *C. strenuus*, comparable to *C. s. abyssorum*, or as an independent species is simply a matter of opinion.

Cyclops strenuus, Fischer (s. lat.).

Female.—Length 1·2–2·3 mm.

Greatest width of thorax about one-third total length of body. Lateral angles of th. soms. 2 and 3 generally a little produced, giving a notched lateral outline. Som. 4 not greatly wider than som. 3, usually pointed, and with the point tending to be recurved; more rarely rounded or with papilliform projections. Som. 5 slightly expanded laterally, with median lateral papilliform process rounded or pointed and sometimes rather procurved. Abdominal somites commonly with posterior ventral margins coarsely toothed, occasionally with cuticle minutely pitted. Genital somite broad

in front, greatest breadth generally equalling or exceeding length, and tapering behind. Receptaculum more or less oval, the anterior part sometimes markedly wider than the posterior part. Furcal rami generally divergent, occasionally almost parallel; inner margin with delicate hairs either throughout or confined to distal third. Dorsal side with conspicuous longitudinal ridge. Outer margin with small notch in anterior third and lateral seta inserted very near end. Length of ramus very variable, 5–8 times as long as wide, and one-sixth to one-eighth length of body. Furcal setæ variable, innermost usually not longer than ramus and less than twice length of outer seta.* Antennule of 17 segments,† longer than th. som. 1, and in some forms reaching back to middle of som. 3. Seg. 12 with æsthetes. Segs. 16 and 17 long and slender, segs. 15–17 each with a line of exceedingly fine hyaline spines, coarser on seg. 15 than on 16 and 17. The line may be interrupted by small gaps. These spines appear to correspond to the hyaline membrane of other forms. Swimming-legs with both rami 3-segmented and exopod 3 usually with 3.4.3.3 spines. Uniting lamella of leg 4 with long hairs on posterior face; coxa with basal and anterior row of spinules. Endopod 1 and 2 of each leg with a group of fine spines on posterior face. Endopod 3, leg 4, rather slender, with 2 terminal spines, of which the inner is much the longer, but usually shorter than the segment. Leg 5 of 2 segments; seg. 1 broad, with long outer feathered seta; seg. 2 about twice as long as broad, with sinuate outer margin and a group of spinules at base of terminal seta on outer angle. Inner spine large, inserted either about middle of inner edge, or nearer end, and reaching beyond end of segment. Spermatophores attached transversely, and usually not reaching beyond sides of genital somite.

* Mrázek (1893c) has figured an abnormal ramus of *C. strenuus* in which the setæ have retained the same proportions as in Copepodid I (see p. 44).

† Spandl (1922, p. 275), records adult specimens with the antennule of 12 segments.

Cyclops strenuus s. str., Fischer.

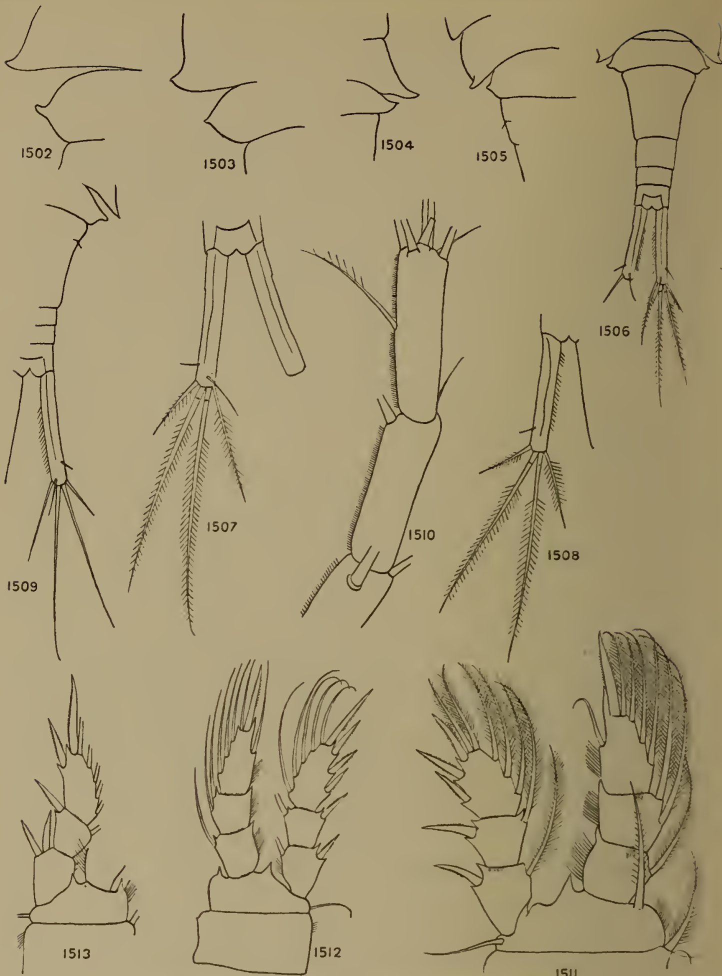
(Figs. 1502–1525.)

1851. *C. strenuus*, Fischer, Bull. Soc. Moscou, XXIV (2), p. 419, figs.
1857. *C. brevicaudatus*, Claus, Arch. Naturgesch. XXIII, 1, p. 34, figs.
1863. *C. lacustris*, Sars, Forh. Vid. Selsk. Christ. 1862, p. 239.
1863. *C. clausi*, Lubbock, Trans. Linn. Soc. XXIV, p. 201, figs.
1878. *C. strenuus*, Brady, Mon. Brit. Cop. I, p. 105, figs.
1878. *C. helleri*, Brady (juv.), *ibid.*, p. 115, figs.
1886. *C. bodamicus*, Vosseler, Jber. Ver. Wurttemb. XLII, p. 103, figs.
1886. *C. strenuus* (part), Vosseler, *ibid.*, p. 195, figs.
1886. *C. lucidulus* (part), Vosseler, *ibid.*, p. 196, figs.
1892. *C. strenuus* (part), Brady, Trans. N. H. Soc. Northd. XI, p. 73, figs.
1892. ,, (part), Schmeil, Bibl. Zool. XI; p. 39, figs.
1901. ,, Lilljeborg, Svenska Akad. Handl. XXXV, p. 28.
1913. ,, Sars, Crust. Norway, VI, p. 32, pl. 16.
1913. *C. lacustris*, Sars, *ibid.*, p. 35, pl. 18.
1918. *C. pictus*, Sars, *ibid.*, p. 211.
1927. *C. strenuus*, Kozminski, Bull. Acad. Cracovie, suppl. I, p. 70.
1929. ,, Kiefer, Thierreich, Lief. LIII, p. 49.
1931. ,, Kiefer, Zool. Anz. XCII, p. 243, figs.
1931. ,, Rzoska, Arch. Hydrob. Ichthyol. V, p. 193.

(For further list of references see Schmeil, 1892.)

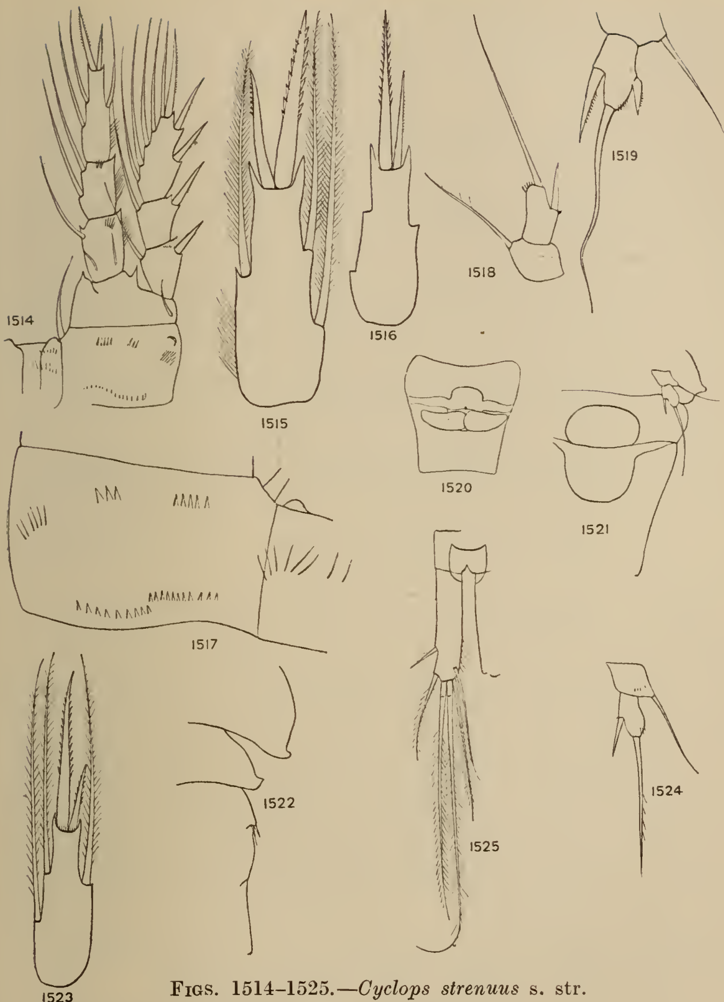
Female.—Length 1·66–2·35 mm.

General form robust; greatest width about one-third total length; soms. 4 and 5 usually very little expanded; som. 4 either produced slightly backwards into a sharp point on either side, or with an outwardly-turned papilliform projection; som. 5 not wider than genital somite, with a small rounded papilla on either side, usually not recurved. Genital somite conical, greatest width exceeding length. Receptaculum oval, the anterior half sometimes wider than posterior half. Furcal rami rather divergent, very variable, from 112°/₀₀ to 154°/₀₀ of body, generally 6–7 times as long as wide (5·3 to 8·7). Inner margin profusely hairy; outer lateral seta inserted very near end (73–87% of ramus); furcal setæ very variable, but inner seta rarely twice as long as outer, and very rarely longer than ramus, usually distinctly shorter. Antennule reaching not further than middle of th. som. 2. Legs with spine-formula 3.4.3.3; variants occasionally met with, but very rare. Leg 4: endopod 3 less than 3 times as long as wide, usually about 2½ times; inner terminal spine



FIGS. 1502–1513.—*Cyclops strenuus* s. str.

FIG. 1502.—Th. soms. 4 and 5. Marlborough.
FIG. 1503.—Th. somites. Ringmere, Norfolk.
FIG. 1504.—Th. somites. Bristol.
FIG. 1505.—Th. somites. Norfolk.
FIG. 1506.—Th. somites and abdomen. Nasratabad, Seistan.
FIG. 1507.—Furcal rami. Marlborough.
FIG. 1508.—Furcal rami. Ringmere.
FIG. 1509.—Abdomen and rami. Suffolk.
FIG. 1510.—Antennule, segs. 15–17, female.
FIG. 1511.—Leg 1.
FIG. 1512.—Leg 2.
FIG. 1513.—Leg 2, exopod, abnormal.



Figs. 1514–1525.—*Cyclops strenuus* s. str.

Fig. 1514.—Leg 4, from behind. Norfolk.
Fig. 1515.—Leg 4, endopod 3. Norfolk.
Fig. 1516.—Leg 4, endopod 3. Oxford.
Fig. 1517.—Leg 4, coxa, from behind. Norfolk.
Fig. 1518.—Leg 5.
Fig. 1519.—Leg 5, abnormal. Ireland.
Fig. 1520.—Receptaculum and spermatophores.

Form from Sutton Broad, Norfolk.

Fig. 1521.—Leg 5 and receptaculum.
Fig. 1522.—Th. soms. 4 and 5.
Fig. 1523.—Leg 4, endopod 3.
Fig. 1524.—Leg 5.
Fig. 1525.—Furcal ramus, male.

Cyclops strenuus strenuus. *Females.*

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
1. Oxford* . . .	1·87	346	154	7·6	87	75	241	262	134	2·45	159	97
2. Cornwall, Helston .	1·90	365	148	7·4	87	67	237	268	121	2·62	170	87
3. ,, Bodmin .	1·88	345	136	7·2	82	69	235	266	128	2·18	200	+
4. Suffolk, Herringfleet* .	1·88	330	138	7·25	83	58	184	219	106	2·65	169	105
5. ,, Flixton . .	1·74	350	126	5·6	76	63	230	265	126	2·8	188	76
6. Norfolk, Spooner Row*	2·35	330	130	6·6	82	57	184	226	85	2·36	167	86
7. ,, Sprowston* .	2·3	331	135	7·6	87	65	204	230	113	2·40	162	—†
8. ,, Sutton Broad.	1·75	330	114	5·6	77	80	217	270	126	2·86	231	102
9. ,, Sutton . .	1·96	286	112	7·3	79	59	189	215	77	2·82	217	97
10. ,, Happisburgh .	1·74	350	126	5·6	79	63	230	264	126	2·82	189	—
11. Marlborough . .	2·25	297	120	7·25	83	62	200	236	107	2·64	177	—
12. Ireland, Kilbarrack .	2·37	360	131	7·0	. .	44	227	280	134	2·17	150	96
13. Bristol . . .	2·05	328	127	6·25	80	68	180	200	112	2·40	184	—
14. ,, . . .	2·00	340	163	8·7	84	75	245	265	125	2·45	175	—
15. Derbyshire . .	1·59	320	145	7·3	85	69	245	290	126	2·86	214	—
16. Seistan, Nasratabad .	2·12	316	137	6·9	76	76	. .	. .	131	2·43	177	76
Males.												
17. Oxford, 1 . . .	1·40	312	132	6·2	78	79	253	290	250	2·8	177	+
18. ,, 2 . . .	1·50	306	130	6·3	82	87	252	340	146	2·54	187	+
19. Norfolk, Sprowston .	1·56	275	104	5·1	76	70	235	280	134	2·7	168	+
20. ,, Happisburgh .	1·47	307	113	4·7	76	85	265	313	156	2·6	177	—
21. Suffolk, Herringfleet .	1·28	314	109	3·75	74	78	250	327	149	2·7	215	+
22. Bodmin . . .	1·30	315	138	5·7	82	92	245	330	154	2·3	208	+
23. Derbyshire . .	1·20	292	133	6·0	77	79	225	325	134	3·0	175	+
24. Seistan, Nasratabad .	1·54	280	121	5·8	77	65	212	280	128	2·43	230	+

* Average measurements.

† In some cases the numerical proportion between the terminal spines and end. 3 of leg 4 was not noted. In such cases + or —

nearly always shorter than seg. 3 and less than twice as long as outer spine.

Male.—Length 1·28–1·56 mm.

Very much smaller and more slender than female. Th. soms. 4 and 5 of the same form as the preceding somites, with acute posterior angles. Furcal rami shorter than in female, often very much shorter, and stouter (see Table); dorsal ridge absent; furcal setæ more slender, and generally considerably longer than in female, the inner seta much longer than the ramus. Leg 4: endopod 3 more slender than in female and with inner terminal spine longer than the segment. Leg 6 consisting of a plate with two nearly equal spines and a long outer seta, more than twice as long as the longest spine.

Variation.

In a species so variable as this it is difficult to decide what form of it should be regarded as "typical." As Kozminski observes, practically every author who has discussed the species finds differences between his specimens and previous descriptions, and there is no satisfactory standard of comparison. Fischer's figures are, naturally, not so exact and complete as is necessary for certainty, but they show a form with very short rami and very short furcal setæ, the longest less than $1\frac{1}{2}$ times as long as the ramus. If Fischer's figure can be taken as accurate, then the figures given by Sars may be accepted as determining the typical form. On the other hand, Kozminski states that he has never seen any specimens with setæ so short, and that is also my own experience. Possibly the typical form may be confined to Scandinavia and North Russia. So far as British specimens are concerned, it is hardly an exaggeration to say that appreciable differences may be found between the populations of any two ponds, even if close to each other, though each population may show

little individual variation. Taking examples from different and widely separated localities the variation is simply bewildering. The differences, except as regards form of thoracic somites, are best expressed numerically (Table, p. 156). Figures are given showing variation in form of thoracic somites, and it will be seen that no fundamental distinction can really be drawn between *C. strenuus* and *C. vicinus* in this respect. It is, indeed, quite misleading to rely much on the form of these somites.

Mr. Lowndes (1932) has given a very valuable table of measurements of the 24 offspring of a single parent. This table shows that even within such a single brood there is quite a wide range of variation in length of ramus, from 111 to 130, the parent having a ramus of 124. The ratio of length to width of ramus in the offspring varied from 4·35 to 6·25, the parent ratio being 7·3. Similar variation was found in other characters. These figures show with what reserve one must accept specific distinctions based upon "plus and minus" characters.

A form which is most difficult to place is one which occurs commonly in certain of the Norfolk Broads (*e. g.* Sutton, Hickling) in winter and spring. It is relatively small, very yellow, and with rounded thoracic somites (Figs. 1521–1525; Table, p. 156, no. 8). It appears to resemble *C. kolensis*, Lillj., very closely, but differs from it in the spine formula, that of *C. kolensis* being 2.3.3.3. *C. kolensis* has been redescribed by Rzoska (1931), and is a plankton species, but, apart from the spine formula, I find it difficult to separate from the Norfolk form. This Norfolk form differs from the type-form in having the inner terminal spine of leg 4 more than twice as long as the outer, and in the more slender endopod 3. In respect of these characters it agrees with *C. s. abyssorum*, from which it is difficult to separate it except by its relatively short rami, and the fact that the inner spine is shorter, or but little longer, than endopod 3.

Distribution in Britain.

The typical form of *C. strenuus* is very common in small ponds throughout England, but there are few records from Wales or Ireland. For Scotland the only record is for Great Cumbrae (D. J. S.).

Distribution Abroad.

Owing to the divergence of opinion as to the limits of the species, it is impossible at present to ascertain the distribution of the typical form with any approach to accuracy. Kiefer (1929) gives "Ganz Europa, Asien, Nordafrika, Nordamerika," which is, perhaps, as much as can be said about it. Its most southern localities are Algeria, Palestine, Chitral, Seistan and Japan.

Habitat, Etc.

References to habitat and seasonal occurrence abound in literature,* but the particular form dealt with is rarely established, and the results are so diverse that it seems hardly worth while to refer to them. Whatever view may be taken of the structural differences, there certainly exist physiological differences between races, some being winter and others summer forms, but whether any of the latter can be referred to *C. strenuus* s. str. or not is most doubtful. Rzoska's account (1927) of the seasonal cycle and structural seasonal variation of two forms from Posen and Lunz are most interesting; but it is not clear with which forms he was dealing.

In this country *C. strenuus* s. str. is found only (with the exception of the Norfolk Broads) in ponds and ditches; often in such as dry up in summer. As a rule its period of active reproduction is restricted to winter and early spring, and it disappears or becomes rare in summer (see Scourfield, 1897, p. 260). For example, a pond near Oxford was first observed on March 3rd, 1929, after severe frost. Adult *C. strenuus* s. str. were then common but not breeding. On March 19th immense

* Principal references · Wolf, 1905; Linder, 1904; Burckhardt, 1920b.

numbers of nauplii had appeared, and this generation matured about the middle of April. The pond became dry in June, and remained so until October. When it filled again the species reappeared, all individuals being in copepodid stage V, and most of them covered with rusty brown matter, as if they had just emerged from cysts in the mud. A month later adults were abundant and breeding, but few nauplii had hatched. The pond did not dry up in that summer, but the species disappeared in June.

Owing to its preference for winter breeding the species has been claimed as a "glacial relict" (see Hofsten, 1912).

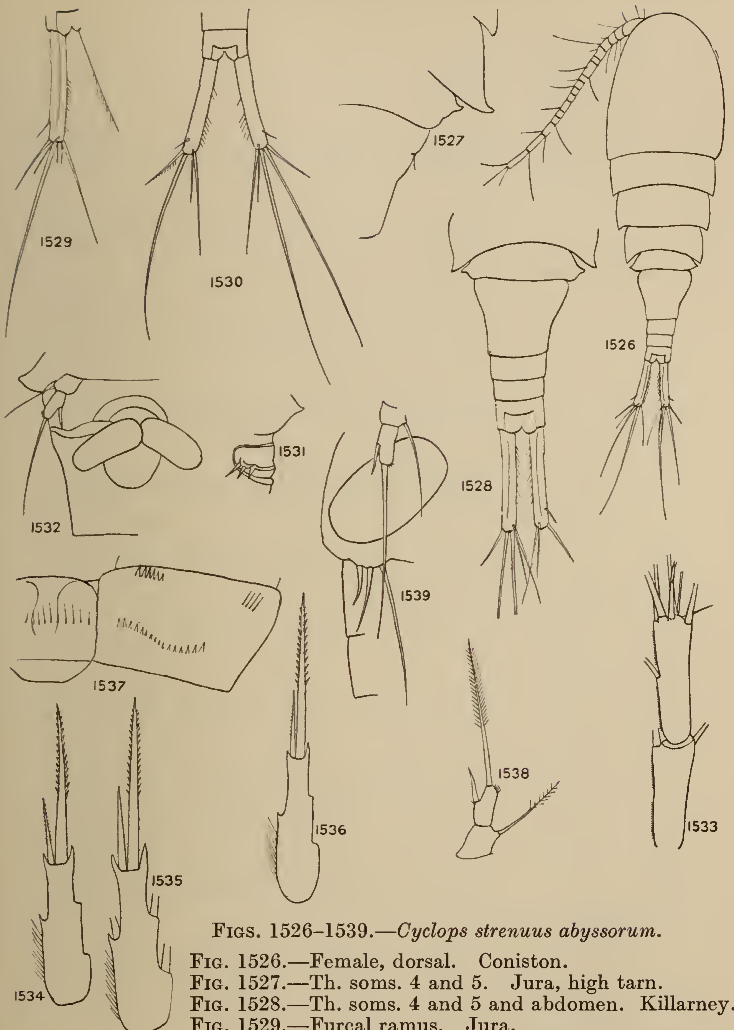
Cyclops strenuus abyssorum, Sars.

(Figs. 1526–1539.)

1863. *C. abyssorum*, Sars, Forh. Vid. Selsk. Christ. 1862, p. 238.
1878. *C. pulchellus*, Brady, Mon. Brit. Cop. I, p. 107, figs.
1888. *C. ewarti*, Brady (juv.), Rep. Fish. Bd. Scot. VI, p. 232, figs.
1892. *C. abyssorum*, Brady, Trans. N. H. Soc. Northd. XI, p. 73, figs.
1893. *C. ewarti*, Scott, Rep. Fish. Bd. Scot. XI, p. 223, figs.
1913. *C. abyssorum*, Sars, Crust. Norway, VI, p. 33, figs.
1923. ,, Gurney, J. Linn. Soc. XXXV, p. 435.
1929. ,, Kiefer, Thierreich, p. 51.

Female.—Length 1·20–1·47 mm.

General form of body and of soms. 4 and 5 as in *C. strenuus*. Furcal rami very variable in length and, on the average, the same as in *C. strenuus*, ranging from 125–165°/₀₀. They are, however, nearly always less slender, being usually about 6 times as long as wide. Position of lateral seta as in *C. strenuus*. Terminal setæ, particularly seta 3, markedly longer than in *C. strenuus*; seta 4 never shorter than ramus and usually considerably longer. Antennule reaching back to end of th. som. 1 or middle of som. 2. Legs with spine formula 3.4.3.3. Leg 4: endopod 3 more slender than in *C. strenuus*, rarely less than 3 times as long as wide; inner terminal spine always longer than endopod 3, and more than twice as long as outer spine. Leg 5 and receptaculum as in *C. strenuus*.



FIGS. 1526–1539.—*Cyclops strenuus abyssorum.*

FIG. 1526.—Female, dorsal. Coniston.
FIG. 1527.—Th. soms. 4 and 5. Jura, high tarn.
FIG. 1528.—Th. soms. 4 and 5 and abdomen. Killarney.
FIG. 1529.—Furcal ramus. Jura.
FIG. 1530.—Furcal rami.Loc h Morar, without dorsal ridge.
FIG. 1531.—Genital opening, female. Orkneys.
FIG. 1532.—Receptaculum and spermatophores. Coniston.
FIG. 1533.—Segs. 16 and 17 of antennule. Shetlands.
FIG. 1534.—Leg 4, endopod 3. Loch Shin, female.
FIG. 1535.—Leg 4, endopod 3. Jura, female.
FIG. 1536.—Leg 4, endopod 3. Jura, male.
FIG. 1537.—Leg 4, coxa, from behind.
FIG. 1538.—Leg 5. Coniston.
FIG. 1539.—Legs 5 and 6, male. Wastwater.

Cyclops strenuus abyssorum. *Females.*

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
Scotland :												
Loch Ness . . .	1·23	325	130	5·6	74	65	316	430	146	3·46	267	+†
,, Shin . . .	1·49	315	140	6·5	77	80	300	363	154	3·0	230	114
,, Lomond . .	1·53	333	137	6·68	80	82	274	326	130	3·15	241	+
,, Ossian . .	1·35	334	126	6·6	76	81	296	340	164	2·85	208	+
,, Shiel . . .	1·32	355	137	6·8	79	83	310	363	159	3·1	270	+
,, Morar . . .	1·15	345	165	5·8	81	81	334	392	156	2·87	262	+
,, Daillich Airbh .	1·35	340	133	6·2	..	67	252	303	134	3·05	235	+
Jura, L. Righ Mor . .	1·38	340	130	5·7	85	75	305	362	140	2·72	281	+
,, High Tarn* . .	1·48	339	150	6·6	83	88	311	358	170	2·82	215	108
Aithness, Shetlands .	1·20	315	125	5·6	77	58	300	392	125	3·5	240	+
Ireland :												
Lough Erne . . .	1·82	340	148	8·1	81	92	258	324	154	2·5	200	+
,, Derg . . .	1·37	357	138	6·2	76	73	..	401	146	3·4	300	+
,, Arrow . .	1·46	324	150	8·4	78	72	280	384	150	3·9	235	+
Killarney . . .	1·54	300	137	8·2	58	62	248	273	108	3·50	259	+
Lake District :												
Coniston* . . .	1·44	348	146	6·9	77·5	76	305	327	146	3·32	230	108
Ullswater . . .	1·43	336	126	6·2	78	77	272	307	133	2·95	236	+
Wastwater . . .	1·38	332	131	5·7	78	70	276	311	123	3·3	237	+
Crummock . . .	1·47	332	144	6·7	83	75	286	340	133	3·18	215	..
Lake of Constance . .	1·41	312	135	7·6	77	66	297	410	135	3·6	2·5	120

Males.

Loch Ossian . . .	1·04	288	125	5·4	74	77	280	380	150	3·27	294	+
,, Shin . . .	1·05	285	130	5·8	75	93	250	370	162	3·85	232	118
Jura, L. Righ Mor . .	1·04	296	116	5·0	73	77	288	420	164	3·06	287	+
,, High Tarn . .	1·18	287	119	5·1	76	85	263	347	158	3·06	194	120
Coniston	1·15	305	122	5·4	74	76	226	305	139	3·36	200	+
Ullswater . . .	1·10	290	115	5·0	75	78	268	355	157	3·85	243	+
Wastwater . . .	1·04	326	116	4·85	74	82	290	384	158	3·74	216	–
Lough Arrow . . .	1·13	310	131	7·2	76	71	257	340	142	4·3	200	–

C. s. tatricus, *Kozminski.* *Females.*

Visalpen, N. Tirol . .	1·75	315	120	6·7	80	86	300	343	160	3·4	187	102
Schwerzwandsee, Karnten.	1·57	319	132	6·2	82	89	286	345	146	3·1	201	103
Groendlingsee, 2100 m. .	1·55	322	135	6·7	78	78	258	310	164	2·66	190	102

* Average.

† In some cases the numerical proportion between the terminal spines and end. 3 of leg 4 was not noted. In such cases + or – indicates that the spine was longer or shorter respectively than the segment.

Male.—Length 1·04–1·2 mm.

Furcal rami generally much shorter than in female, less than 6 times as long as wide, without dorsal ridge. Furcal setæ much as in female, never much longer and sometimes even a little shorter. Lateral seta inserted a little further forward. Leg 4: endopod 3 more slender than in female, always more than 3 times longer than wide. Inner terminal spine about the same length as in female, rarely a little shorter than segment. Leg 6 with strong ventral spine and two rather slender setæ, of which the dorsal one is more than twice as long as the ventral.

Synonymy and Variation.

Sars states (1913, p. 34) that *C. strenuus* var. *gracilipes*, Sars (1903, p. 217), from Lake Telecki in Altai is identical with *C. abyssorum.* Specimens from Lake Telecki in the Norman Collection which are labelled (by Sars) as *C. gracilipes* are actually *C. leuckarti.* No description of this form was given by its author.

The description given above, from British specimens, differs from that of Sars in some important respects. His figure of the receptaculum is unlike anything I have ever seen, and I have never seen specimens with rami so slender. Brady, however, states that specimens from Windermere or Coniston were submitted to Sars and identified as *C. abyssorum.* The resemblance to *C. strenuus* is so close that no clear-cut distinction between the two can be drawn. In Britain, however, there is a definite geographical limitation associated with biological differences which make it desirable, at present, to keep the two forms separate. On the other hand, if one takes also into consideration specimens from other parts of the world, even such small distinctions as are here drawn break down.

Peculiar difficulty is found in naming the forms of *C. strenuus* from the far north. Olofsson (1918, p. 480) was unable to refer those from Spitzbergen to any form described by Sars. He distinguished two forms, one

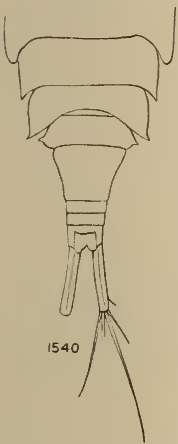
of them very closely resembling *C. abyssorum*, but apparently both forms might occur together. Ekman (1923) describes a very similar form from Novaya Zemlya which he regarded as transitional between *C. lacustris* and *C. abyssorum*. Rylov again (1925, p. 314) found a form in eastern Manchuria intermediate between *C. strenuus* and *C. abyssorum*, but in one sample the same form was taken in company with "echtes var. *abyssorum*." The following table gives measurements of specimens from 13 localities on Bear Island, collected by Mr. Bertram. It will be seen that there is much variation in length of rami and of furcal setæ, but that leg 4, endopod 3, is in nearly all cases very slender, and the furcal setæ generally longer than in *C. strenuus*, though nearly always shorter than the ramus. There is not much variation in form of th. soms. 4 and 5, except that the former is simply rounded in one case (loc. F.). It can hardly be doubted that all belong to the same race, and it is so exactly intermediate between *C. strenuus* and *C. abyssorum* that no distinction is possible. The specimens from loc. L are exceptional, however, in the extremely short rami. This particular form might be definitely assigned to *C. strenuus*. The conclusion seems to be that neither *C. lacustris* nor *C. abyssorum* can be maintained either as species or subspecies, but that they are simply variants of *C. strenuus*, to which they are united by every possible transition. On the other hand, the existence of these baffling intermediate forms may, one hopes, ultimately receive explanation, and it seems that science is best served in this case by distinguishing subspecies, however inadequately, than by allowing them to sink into the obscurity of mere synonyms.

Closely allied to *C. s. abyssorum* is a form from the Tatra and eastern Alps which Kozminski has described, and which he regards as a distinct species—*C. tatricus* (1932). This is a planktonic species of the colder lakes from 600 to 2000 m. It is characterized by the peculiar form of the somite of leg 2, by which it may be easily

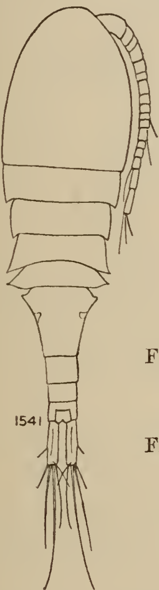
Cyclops strenuus. *Bear Island.*

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
1. Locality A 25 .	1·65	332	146	6·7	78	79	. .	. .	130	3·22	217	93
2. ,, B 24 .	2·20	300	146	8·7	78	77	218	242	130	3·75	188	82
3. ,, ,, ♂ .	1·56	262	128	7·8	79	83	250	. .	146	3·3	186	93
4. ,, C 40 .	1·85	335	151	7·7	79	70	242	285	119	3·0	217	78
5. ,, D 28 .	1·75	285	128	6·2	81	63	227	262	114	3·3	196	96
6. ,, E 36 .	1·62	. .	160	7·8	78	77	300	. .	154	3·8	210	88
7. ,, F 27 .	1·67	330	122	5·3	76	68	257	. .	128	3·2	218	100
8. ,, ,, .	1·81	. .	132	7·0	76	66	255	. .	127	2·92	230	100
9. ,, ,, .	2·15	297	130	6·6	79	70	225	. .	116	3·2	192	86
10. ,, G 44 .	2·05	326	151	7·4	82	73	230	290	126	3·3	200	85
11. ,, H 1 .	1·45	337	142	6·0	85	83	290	. .	138	2·83	230	104
12. ,, I 2 .	2·32	323	138	6·9	82	69	245	292	127	2·95	205	92
13. ,, J 8 .	1·95	353	138	6·5	77	79	246	290	144	2·6	200	93
14. ,, K 9 .	1·58	347	146	7·4	81	78	285	335	133	3·4	227	91
15. ,, ,, ♂ .	1·3	310	132	6·2	76	81	. .	. .	154	3·94	227	93
16. ,, L 13 .	1·35	332	115	4·6	75	74	247	. .	115	2·7	217	109
17. ,, M 17 .	1·57	343	128	5·4	78	79	. .	. .	134	3·1	212	83
Average ♀ . .	1·79	326	138	6·7	79	74	251	285	129	3·15	211	98

recognized (Fig. 1540), and by the proportional lengths of rami and setæ, which can only be expressed statistically. I have, by the kindness of Dr. Pesta, been able to examine specimens of "*C. strenuus*" from several localities in the eastern Alps, and find all to be of this form. Measurements are given in table (p. 163). Geographically and ecologically limited as this form



1540



1541

FIG. 1540.—*C. strenuus tatricus*, th. soms. 2–5 and abdomen, female. Groendlingsee, Tirol.

FIG. 1541.—*C. scutifer*, female, dorsal. Lapland.

appears to be, it is certainly right that it should be distinguished; but there are some advantages in regarding it as a subspecies of *C. strenuus* rather than as a separate species.

DISTRIBUTION IN BRITAIN.

Throughout Scotland, and in the Lake District, this is the common form of *C. strenuus*. It is found not only in the plankton of most lakes, but also in small tarns at all elevations. In Jura it was found in one small elevated tarn, and in one only of the lakes. It seems to be associated in this country with water of low pH, and to be confined to what may be called the

"Desmid Region." The plankton form of *C. strenuus* from the Irish Lakes may also be referred to *C. s. abyssorum* (Lough Derg, L. Erne, L. Arrow, etc.).

Distribution Abroad.

Norway (Sars, Huitfeldt-Kaas).
Sweden (Lilljeborg, Ekman).
Germany (Schauss).
Switzerland (Thiébaud, v. Hofsten).
Manchuria (Rylov).
Spitzbergen (Olofsson).
Bear Island (Elton, Bertram).
Novaya Zemlya (Ekman).

Bionomics.

Sars and others (*e. g.* Hofsten) state that this is a deep-water form of lakes and is rarely taken in the plankton at the surface. This is by no means the case in Scotland, where it may be found in shallow tarns and at all depths in the lakes. There is even some evidence for a preference for the upper layers. For example, in Loch Shin (August, 1928), although it was very rare in the shallow eastern half of the loch, it was abundant in the main lake at the surface, and became less numerous in deeper layers :

	Surface.	50–60 ft.	120–130 ft.
Per cent. of catch .	64 .	12 .	1·6–·85

In the lake district, on the contrary, there seems to be some preference for the deeper waters. For example in Wastwater (September 30th, 1922) :

	Surface.	80 ft.	100 ft.	120 ft.
Per cent. of catch .	17·9 .	30 .	24 .	12

Such evidence as is available seems to prove *C. s. abyssorum* to be a monocyclic species, with breeding period in late summer and autumn (Gurney, 1923, p. 436). Adults are very rare or absent from plankton from the Lake District in spring. From Scotland there

is little evidence, since most of the collecting has been done in summer. From Loch Ness there is a series of samples (Scottish Survey) from July to December. They show the species in full reproduction in July, but adults disappearing in September, to be replaced by a new generation in December of adults not sexually mature.

In Spitzbergen there is only one reproductive period—in autumn (Olofsson, 1918), p. 487. The young of this generation reach maturity by end of autumn or during the winter, and the former produce eggs which do not develop until spring. Those that mature late in winter or in spring produce eggs which develop directly in the rising temperature. The adults die after breeding.

Southern and Gardiner (1932, p. 150) find, in Lough Derg, that the vertical distribution of the males differs from that of females and young, showing a preference for the deeper layers at all hours, whereas females and young move to the upper 2 metres during the night. There is thus a marked bimodal night distribution.

Cyclops scutifer, Sars.

(Fig. 1541.)

1863. *C. scutifer*, Sars, Forh. Vid. Selsk. Christ. 1862, p. 237.
1898. ,, Sars, Ann. Mus. St. Pet. III, p. 349, figs.
1901. ,, Lilljeborg, Svenska Akad. Handl. XXXV, p. 33, figs.
1912. *C. strenuus*, Marsh, Proc. U.S. Nat. Mus. XLII, p. 249, figs.
1913. *C. scutifer*, Sars, Crust. Norway, VI, p. 36, figs.
1927. ,, Kozminski, Bull. Acad. Cracovie, Suppl. I, p. 68, figs.
1929. ,, Kiefer, Thierreich, Lief. LIII, p. 51.

Female.—Length 1·2–1·4 mm.

Th. soms. 4 and 5 with pointed lateral expansions as in *C. vicinus*; genital somite very broad in front, greatest width exceeding length, its anterior outer angles usually with a small papilliform projection. Furcal rami short, about 4 times as long as wide, with dorsal ridge and hairs on inner margin; lateral seta inserted just beyond middle (62%); inner terminal seta nearly $1\frac{1}{2}$ times as long as ramus; seta 3 much longer than seta 2. Antennule extending to end of th. som. 2 or just beyond it. Legs with spine formula

3.4.3.3. Endopod 3 of leg 4 nearly 3 times as long as wide; inner terminal spine longer than segment and 3 times as long as outer spine. Receptaculum oval. Spermatophore attached obliquely, and projecting beyond margin of somite. Egg-sac small, with few eggs.

DISTRIBUTION.

Novaya Zemlya (Ekman).
Sweden (Lilljeborg).
Norway (Sars).
North Siberia (Sars).
Russia (Rylov).
Poland (Kozminski).
Canada (Willey).
New York, U.S.A. (Marsh).

This is the commonest limnetic species in Norway and Sweden, and the only limnetic species in the high lakes of Norway (Huitfeldt-Kaas). It has not been found in Britain, but it is not impossible that it has been overlooked.

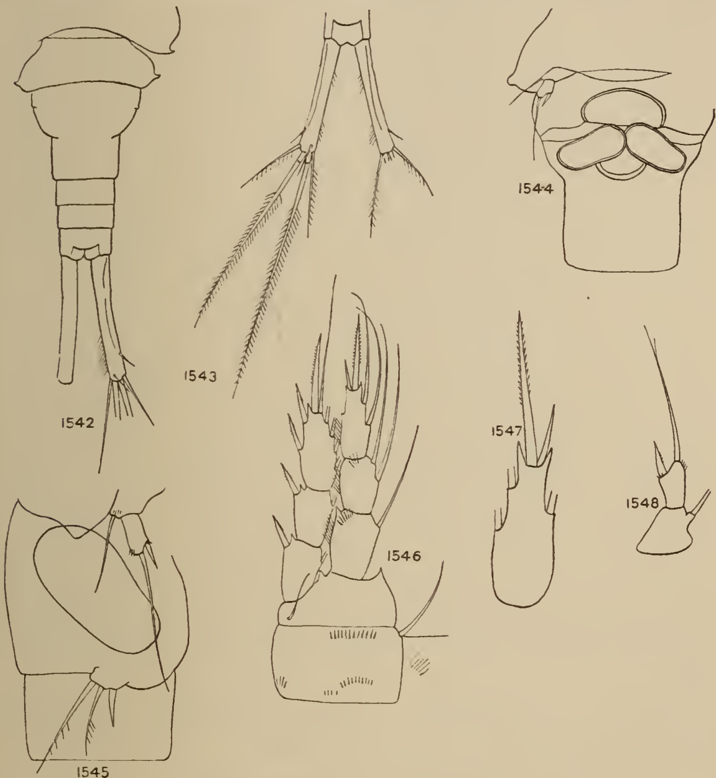
Schmeil regarded *C. scutifer* as merely a limnetic variety of *C. strenuus*. Kozminski found two forms of it, one of them (*C. s. wigrensis*) living in eutrophic conditions, and showing that the features characteristic of the species are not solely due to planktonic life. That these features are not the product of the environment is also suggested by the fact that the limnetic forms of *C. strenuus* (*C. s. abyssorum* and *C. lacustris*) do not have expanded somites, while *C. vicinus*, which has these somites greatly expanded, lives commonly in small ponds.

Cyclops furcifer, Claus.

(Figs. 1541–1548.)

1857. *C. furcifer*, Claus, Arch. Naturg. XXIII, 1, p. 208, figs.
1901. *C. miniatus*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 24.
1926. *C. lacunæ*, Lowndes, Ann. Mag. Nat. Hist. (9), XVIII, p. 142, figs.
1927. *C. miniatus*, Kiefer, Arch. Balaton, I, p. 412, figs.
1927. *C. strenuus* f. *furcifer*, Kozminski, Bull. Acad. Cracovie, Suppl. I, p. 72, figs.
1929. *C. furcifer*, Kiefer, Thierreich, Lief. LIII, p. 51.

I follow Kozminski in reviving Claus's name for this species with much reluctance, since Claus's description is quite insufficient to determine the species. Un-



FIGS. 1542–1548.—*Cyclops furcifer.*
FIG. 1542.—Abdomen, dorsal, female.
FIG. 1543.—Furcal rami, dorsal, female.
FIG. 1544.—Receptaculum and spermatophores.
FIG. 1545.—Legs 5 and 6, male.
FIG. 1546.—Leg 4, from behind.
FIG. 1547.—Leg 4, endopod 3.
FIG. 1548.—Leg 5, female.

fortunately Claus's name has been accepted by Kiefer, and it is used here to avoid further change.

Female.—Length 1·44–2·10 mm.

Th. som. 4 slightly expanded, rather variable; angles either tapering to a point, or with a rounded or pointed

and slightly procurved process. Th. som. 5 with a small sharply pointed and procurved process on either side. Genital somite broad in front, width slightly less than total length, sharply constricted and cylindrical in region behind receptaculum. Receptaculum with anterior portion markedly wider than posterior, more or less pear-shaped. Spermatophores attached transversely, and not reaching outer margin of somite. Furcal rami very long and slender, 8–9 times as long as wide, and about one-seventh of total body length; dorsal ridge present; inner margin with sparse hairs; lateral seta inserted not quite so near end as in *C. strenuus*; inner seta shorter than ramus, and not much longer than outer seta. Seta 3 much longer than seta 2. Antennule reaching to middle of th. som. 2. Swimming-legs with spine formula very variable, usually 2.3.3.3, but commonly also 3.4.3.3. Lowndes (1927) gives results of breeding experiments showing that, from the progeny of parents with the same formula, no less than 9 different variants were obtained. Leg 4: endopod 3 rather stout, less than 3 times as long as wide. Outer apical spine much longer than end. 3 and about $2\frac{1}{2}$ times as long as inner spine. Leg 5 as in *C. strenuus*. Egg-sacs smaller than in *C. strenuus*, but with numerous eggs.

Colour a conspicuous orange, obscured in mature females by the dark brown ovaries.

Male.—Length 1·17–1·55 mm.

Furcal rami not much shorter than in female, but comparatively less slender and without dorsal ridge. Furcal setæ not differing much from those of female. Leg 6 with stout ventral spine and two slender setæ, of which the dorsal one is little if at all the longer.

This species is readily distinguished from typical *C. strenuus* by its conspicuous colour, the form of th. som. 5 and of the genital somite, and also by the very slender rami. The inner furcal seta is considerably shorter, and the outer apical seta of leg 4 endopod is

Cyclops furcifer.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
Marlborough, ♀*	1·62	345	142	8·5	79	80	247	308	97	2·4	247	123
,, ♂*	1·17	315	145	6·9	74	77	271	341	93	2·4	247	120
Oxford, ♀*	1·99	300	133	8·9	77	71	226	296	83	2·6	224	110
,, ♂*	1·55	290	129	6·2	74	77	222	301	103	2·8	256	106

* Average measurements.

much shorter. On the other hand, certain forms which are referred to *C. strenuus* may, in some characters, show transitions to *C. furcifer.* For instance *C. s. abyssorum* has the same difference in the length of the apical spines of leg 4, while the race from the Norfolk Broads not only has the same relation between these spines, but also resembles it in the rather more forward position of the lateral seta on the ramus. Lilljeborg considered that it might perhaps be regarded as a variety of *C. strenuus*, and Kozminski treats it as such ; but it seems better to regard it as a distinct species. In spite of some more or less transitional forms, I have found no form of *C. strenuus* which could be confused with it. Both Kiefer and Kozminski record its occurrence together with *C. strenuus*, and the former states that he has in such cases had no difficulty in distinguishing the two. Still stronger evidence of its specific distinction is the fact that Mr. Lowndes finds that it will not cross with *C. strenuus* (Lowndes, 1932a).

Distribution in Britain.

Discovered by Mr. Lowndes in 1926 in three small ponds near Marlborough. I have myself found it only in a disused quarry at Bayworth, near Oxford.

Distribution Abroad.

France : La Sarthe (Roy).
Hungary : Buda Pesth (Jungmayer, Kiefer).
Russia : Poltawa (Kiefer).
Poland (Kozminski).
Sweden (Lilljeborg).
Algeria (Gauthier).

Habitat, Etc.

In Britain hitherto only found in winter and spring in pools drying up in summer. Apparently this is also true as a rule for its occurrence abroad.

Roy (1932, p. 168) has proved that both adults and eggs can survive desiccation. The adults do not form cysts, but become simply opaque during the resting period.

Cyclops vicinus, Uljanin.

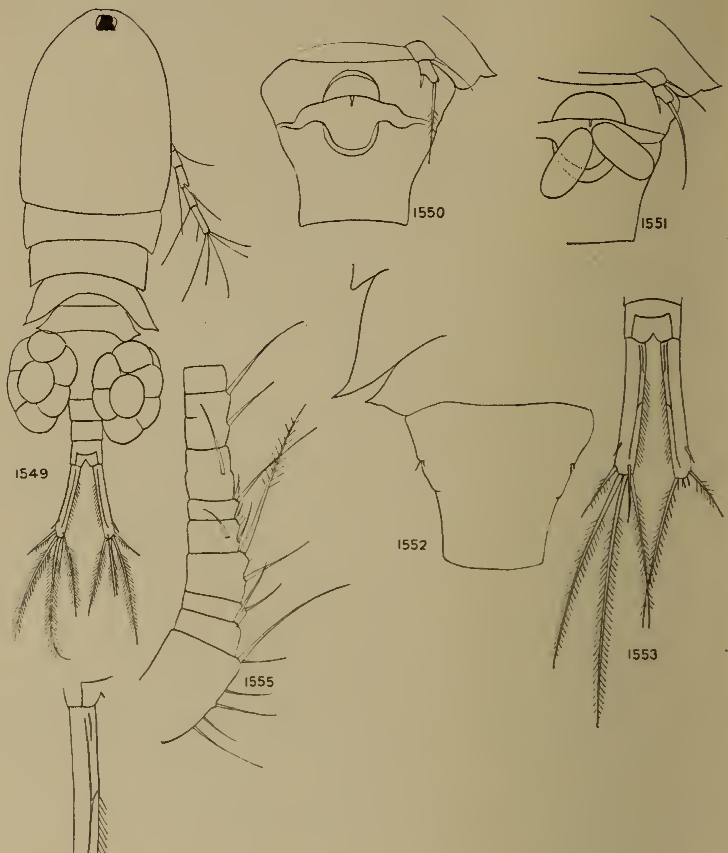
(Figs. 1549–1562.)

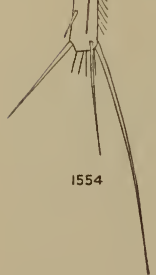
1875. *C. vicinus*, Uljanin, Crust. v. Turkestan, p. 30, figs.
1886. *C. lucidulus*, Vosseler, Jber. Vaterl. Nat. Wurtt. p. 194, figs.
? 1892. *C. vicinus*, Brady, Trans. N. H. Soc. Northd. XI, p. 77, figs.
1892. *C. strenuus* (part), Schmeil. Bibl. Zool. XI, p. 39.
1900. *C. v.* var. *glacialis*, Lilljeborg, Bih. Svenska Akad. Handl. XXVI, Afd. 4, p. 12.
1901. *C. vicinus*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 26, figs.
1903. ,, Sars, Ann. Mus. St. Petersb. VI, p. 22, figs.
1913. ,, Sars, Crust. Norway, VI, p. 37, figs.
1922. ,, De Lint, Int. Rev. Hydrob. X, p. 76, figs.
1927. ,, Kozminski, Bull. Acad. Cracovie, Suppl. I, p. 69.
1929. ,, Kiefer, Thierreich, Lief. LIII, p. 52.
1932. *C. kikuchii*, Smirnov, Annot. Zool. Jap. XIII, p. 283, figs.

It is impossible to ascertain with certainty to which forms Brady's names really apply. It is obvious from the localities cited that he has often confused two or more together. For instance it is impossible to believe that *C. vicinus* occurs in Loch Achray and Loch Katrine, whereas it is certain that he had this species from other localities, and quite possible that his figures were taken from them. His *C. pulchellus* appears also to be a mixture, but his figures seem to have been taken from *C. s. abyssorum*.

Female.—Length 1·44 mm.–1·85 mm.

Body rather slender, greatest width of th. som. 1 less than one-third of total length; th. som. 4 with angles backwardly produced into long pointed wings, the greatest width exceeding width of som. 3; som. 5 with pointed lateral expansions, much wider than genital somite. Genital somite conical, greatest width about equal to length, or a little exceeding it. Receptaculum variable, either elongate oval (Fig. 1550), or nearly circular in outline of middle part (Fig. 1551). I have seen none exactly of the form shown by Lilljeborg or

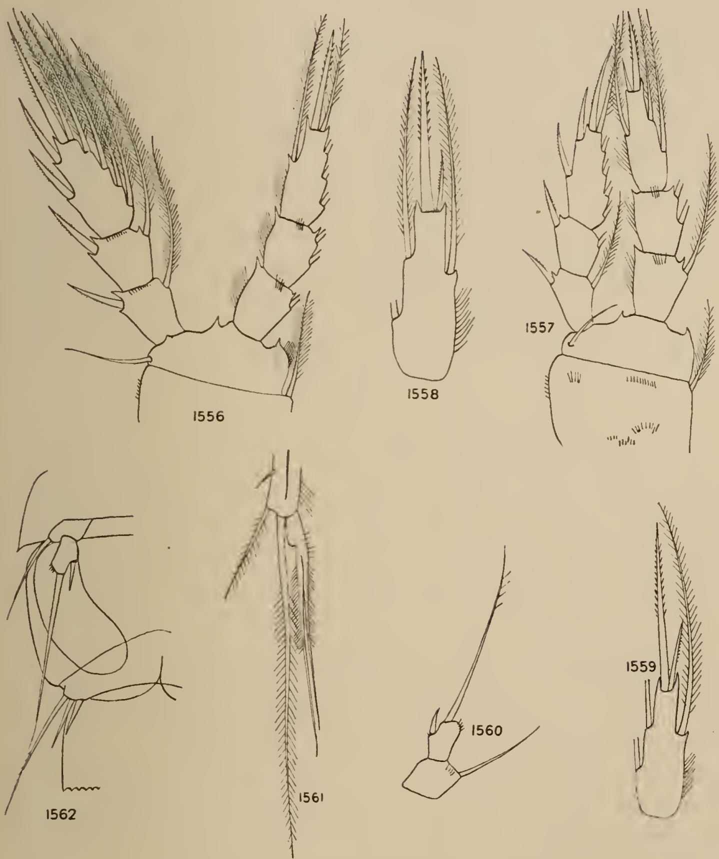




FIGS. 1549–1555.—*Cyclops vicinus.*

FIG. 1549.—Female, dorsal. Ormesby Broad.
FIG. 1550.—Receptaculum.
FIG. 1551.—Receptaculum, with spermatophores.
FIG. 1552.—Th. soms. 4 and 5, and genital somite. R. Bure.
FIG. 1553.—Furcal rami, dorsal. Corton.
FIG. 1554.—Furcal ramus, dorsal. Ormesby.
FIG. 1555.—Antennule, female, basal segments.

De Lint. Spermatophores attached obliquely, and not projecting beyond somite.



FIGS. 1556–1562.—*Cyclops vicinus.*

FIG. 1556.—Leg 2.
FIG. 1557.—Leg 4, from behind.
FIG. 1558.—Leg 4, endopod 3, female. Swindon.
FIG. 1559.—Leg 4, endopod 3, male. Swindon.
FIG. 1560.—Leg 5.
FIG. 1561.—Furcal ramus with abnormal setæ. Ormesby.
FIG. 1562.—Legs 5 and 6, male.

Furcal rami very long and slender; length 7–8 times width and 132–156°/$_{oo}$ of body; dorsal ridge as a rule very conspicuous, and generally with a characteristic

obliquely transverse inner branch (Fig. 1554); near the base there is usually a short ridge running parallel to and inside the dorsal ridge; inner margin very hairy; outer seta inserted a trifle further forward than in *C. strenuus*. Inner furcal seta more than double length of outer and much longer than ramus. Antennule not reaching beyond middle of th. som. 2; segs. 8 and 9 partially fused. Legs with spine formula 2.3.3.3. I have seen no variation in this respect. Leg 4: endopod 3 nearly or quite 3 times as long as wide; inner terminal spine 2–2·8 times as long as outer, but nearly always shorter than segment. Outer spine very short and slender. Leg 5 as in *C. strenuus*. Egg-sac large, with many eggs.

Male.—Length 1·18–1·46 mm.

More slender than female, and with th. soms. 4 and 5 not expanded. Furcal rami without dorsal ridge, shorter and stouter than in female. Leg 4: endopod 3 as in female, or more slender; inner terminal spine always longer, and sometimes very much longer, than the segment. Leg 6 with dorsal seta more than double length of middle seta.

This species is now generally recognized as distinct. While there are forms of *C. strenuus* in which th. som. 4 is expanded in much the same way as in *C. vicinus*, the difference between the two is always appreciable. The partial fusion of segs. 8 and 9 of the antennule, and the great length of the inner furcal seta, are the most reliable distinguishing characters.

De Lint (1922) gives some statistical information relative to the width of th. som. 4, from which she deduces a strong difference between the two species; but she does not appear to have met with any form of *C. strenuus* in which this somite is, as is so often the case, expanded.

Lilljeborg's var. *glacialis*, from Bear Island, was distinguished by its smaller size, less pronounced expansion of th. soms. 4 and 5, in which it approached

Cyclops vicinus. *Females.*

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
Ormesby Broad, Norfolk, 14.xi.27*	1·49	306	142	7·3	78	70	248	295	174	2·92	236	106
,, ,, 9.ii.28*	1·68	290	146	7·7	77	74	235	290	178	3·37	200	92
,, ,, 16.iii.28*	1·86	300	146	7·1	77	73	226	266	167	2·97	238	84
,, ,, 25.v.28*	1·66	340	146	8·3	77	73	231	260	154	2·90	232	97
,, ,, 22.vi.26*	1·62	275	146	9·0	..	62	190	240	136	2·95	213	91
,, ,, 27.ix.28*	1·58	285	140	7·2	..	70	222	260	158	2·85	250	100
,, ,, 14.xi.27	1·80	..	144	7·2	80	87	245	288	173	2·95	197	74
Rollesby Broad, 9.iii.06* . .	1·59	290	145	8·2	78	69	226	285	170	3·1	272	96
Wroxham Broad, 2.vi.05* .	1·58	280	140	8·4	77	76	197	243	160	2·62	277	97
Fritton Lake, 23.vi.19* . .	1·60	307	156	7·8	77	72	212	247	150	2·96	210	93
Swindon (Reservoir)* . .	1·77	282	132	8·0	83	62	215	266	163	3·0	261	86
Birmingham	1·60	287	150	8·4	77	75	218	250	164	2·75	230	+†
Corton (pond), 15.xi.03* . .	1·85	315	159	7·3	80	77	227	284	179	2·72	278	89
Chard Reservoir . . .	1·84	310	158	8·1	77	71	212	262	168	3·12	248	79
Males.												
Ormesby, 14.xi.27 . . .	1·40	256	135	6·7	76	71	214	286	175	2·90	250	108
,, ,, . . .	1·18	255	131	6·0	76	68	204	..	169	2·90	245	133
,, 9.ii.28 . . .	1·30	268	138	6·3	74	77	215	320	185	3·50	260	116
,, 16.iii.28 . . .	1·43	244	136	6·3	76	67	230	286	175	3·10	223	124
Rollesby, 9.iii.06 . . .	1·28	250	133	6·6	76	62	215	280	178	3·5	205	114
Wroxham, 2.vi.06 . . .	1·27	260	110	6·2	77	72	196	300	158	3·7	203	144
Swindon	1·43	216	118	6·3	76	56	182	273	140	3·2	292	118
Birmingham	1·24	210	123	5·5	80	61	200	258	157	2·7	225	+
Corton	1·43	265	140	6·3	76	68	217	279	171	2·64	241	120

* Average measurements.

† In some cases the numerical proportion between the terminal spines and end. 3 of leg 4 was not noted. In such cases + or − indicates that the spine was longer or shorter respectively than the segment.

Cyclops vicinus. *Bear Island.*

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
1. Locality A 11 . .	1·45	. .	145	7·4	76	69	. .	. .	145	2·85	183	93
2. ,, B 15 . .	1·38	305	152	7·5	74	79	275	332	185	3·1	233	109
3. ,, C 21 . .	1·53	287	130	5·9	74	. .	. .	. .	. .	3·0	240	97
4. ,, ,, ,, . .	1·76	272	125	7·2	75	63	244	267	165	3·07	237	102
5. ,, D 27 . .	1·5	265	126	6·2	73	60	240	300	146	3·45	247	108
6. ,, ,, ,, . .	1·47	272	129	7·1	73	62	245	306	163	3·45	247	106
7. ,, ,, ,, . .	1·45	. .	145	7·4	76	69	. .	. .	145	2·85	183	93
8. ,, E 28 . .	1·61	280	130	7·6	74	68	248	272	174	2·5	221	107
9. ,, F 37 . .	1·35	267	126	5·4	78	. .	244	. .	148	2·9	290	116
Average . . .	1·5	278	133	6·8	76	67	249	295	159	3·02	231	103

C. strenuus, and absence of hairs on last segments of antennule. I have examined many specimens from Bear Island, collected by Mr. G. C. L. Bertram, and give measurements of specimens from six localities. There is great variation in form of th. soms. 4 and 5, and also in length of furcal rami. While none reach quite the size sometimes attained in this country, there is no very marked distinction on the whole. I find no difference in the antennule, the last segments having the usual row of hairs, and the majority have 17 segments.

Distribution in Britain.

Norfolk: The commonest planktonic species of *Cyclops*, but also found occasionally in small ponds, generally associated with *Daphnia pulex*.
Hertfordshire: Berkhamsted (Popple).
Essex: Epping Forrest (D. J. S.).
Cheshire: Winsford (D. J. S.).
New Forest (R. G.).
Kent: Tonbridge (R. G.).
Dorsetshire: Swanage (R. G.).
Wiltshire: Marlborough (A. G. L.).
Berkshire: Bayworth (R. G.).
Scotland: Crombie Reservoir, Dundee (R. G.).
Cornwall: Launceston (R. G.).
Somersetshire: Petherton, Taunton (R. G.).

Distribution Abroad.

Norway (Sars).
Sweden (Lilljeborg).
Germany (Kiefer).
Holland (De Lint).
Russia (Meissner, Rylov).
Transcaspia (Walter).
Turkestan (Van Douwe).
Mesopotamia (R. G.).
Kolguev (Zykoff).
Mongolia (Sars).
Poland (Kozminski).
North Persia (Rylov).
S.E. China (Kiefer).
Canada (Marsh).
Bear Island and Spitzbergen (Lilljeborg, R. G.).

Habitat, Etc.

An interesting peculiarity of the species is that it can, without apparent structural difference, live equally well in the plankton of lakes and in small duck-ponds, often in company with *C. strenuus*. Lowndes (1928) gives its range of tolerance to pH as 6·2–8·1, and it may be regarded as confined to "eutrophic" waters.

Lilljeborg notes its occurrence in Ekoln at considerable depths in company with *C. s. abyssorum*, and also in the stomach of *Coregonus albula* in Mälaren. He regards it as a southern form.

Unlike *C. strenuus*, it is chiefly a summer form, though surviving through the winter in some conditions. In the Norfolk Broads it is found breeding throughout spring and summer, but seems to have a maximum in early spring, and a less intense period in late summer. Measurements of a few individuals at different seasons in Ormesby Broad show differences which are not easy to account for, and may point to some seasonal variability, but the facts are not sufficiently complete to establish it.

Subgenus **ACANTHOCYCLOPS**, Kiefer.*

Syn.: 1892. *bicuspidatus*-group, Schmeil, Bibl. Zool. XI, p. 75.

1927. *Megacyclops, Acanthocyclops, Diacyclops* (part), Kiefer, Zool. Anz., LXXIII, p. 305, 306.

1929. ,, ,, ,, ,, Kiefer, Tierreich, LIII, pp. 52, 54, 58.

Antennules without hyaline membrane or marginal spinules; furcal rami without dorsal ridge, generally without inner marginal hairs; swimming-legs with rami of 3 segments, at least in legs 3 and 4, but 2-segmented in a few species of special habitat; leg 5 of 2 segments, rarely with seg. 1 partly or completely fused with th. som. 5; seg. 2 with long apical seta and inner or sub-apical spine, this spine very small when not near apex.

Type.—*C. viridis*, Jurine.

* The selection of a name for a subgenus resulting from the union of two or more subgenera is governed by Art. 28 of the International Rules. In this case it seems that recommendation *a* may apply, on the ground that the diagnosis of *Acanthocyclops* is most pertinent.

Key to the Species of Subgenus Acanthocyclops.

1. Antennule of 17 segments . . . . 2.
   Antennule of less than 17 segments . . . . 9.
2. Leg 5 seg. 2 inner spine very small, in middle of segment; rami with inner margin hairy . . . . . . 3.
   Leg 5 seg. 2 inner spine nearly apical; rami not hairy on inner side . . . . 5.
3. Inner furcal seta more than twice as long as outer . *C. viridis.*
   This seta little longer than outer seta . . (*C. gigas.*) 4.
4. Leg 4, endopod 3 more than $2\frac{1}{2}$ times as long as wide *C. gigas* s. str.
   This segment rarely more than twice as long as wide *C. g. latipes.*
5. Receptaculum butterfly-shaped; exopod 1 of legs 1–4 without inner seta . . . . . *C. sensitivus.*
   Receptaculum not so shaped; exopods with inner seta . 6.
6. Inner furcal seta shorter than outer; inner apical spine of leg 4 endopod longer than outer . . *C. bisetosus.*
   Inner seta longer than outer; inner apical spine generally shorter than outer . . . . 7.
7. Inner spine of leg 5 long; posterior part of receptaculum large . . . . *C. bicuspidatus.*
   Inner spine very small; posterior part of receptaculum very narrow . . . . . .(*C. vernalis.*) 8.
8. Leg 4 endopod 3 broad (1·9–2·5 times as long as wide). Receptaculum as fig. . . . *C. vernalis* s.str.
   This seg. narrow (2·6–2·94). Receptaculum as fig. *C. v. americanus.*
9. Antennule of 16 segments . . . . *C. languidus.*
   Antennule of 14 segments . . *C. bicuspidatus lubbocki.*
   Antennule of 12 segments . . . . . . 10.
   Antennule of 11 segments . . . . . . 11.
10. Furcal rami with inner side hairy; exopod 3 with 5 inner setæ . . . . . . *C. venustus.*
    Rami not hairy; exopod 3 with 4 setæ. . *C. crassicaudis.*
11. Furcal rami, lateral seta in middle . . . *C. nanus.*
    This seta near end of ramus . . . *C. languidoides.*

The Viridis-vernalis Group.

In Kiefer's recent revision a sharp distinction is drawn between *C. viridis* and *C. vernalis*, and each is made the type of a separate subgenus—*Megacyclops* and *Acanthocyclops* respectively. In my opinion such a distinction cannot be drawn. So closely are the

species of these two subgenera related that, especially in American literature, species now regarded as synonyms of *C. vernalis* (*e.g. C. parcus, C. americanus*) have been treated as varieties of *C. viridis*. According to Kiefer's diagnosis, the only distinguishing character is the position of the inner spine on leg 5 ; but this difference is so minute that it cannot outweigh the other more important resemblances. There is no fundamental difference in the form of the receptaculum or of the legs, and, though it would be possible to attach importance to the presence or absence of hairs on the rami, this character becomes valueless when *C. venustus* is drawn into comparison. In fact *C. venustus* and *C. capillatus* together completely bridge any generic gap there may be between *C. viridis* and *C. vernalis*. While *C. capillatus*, by reason of its elongated, smooth rami, with short inner apical seta, seems definitely related to *C. vernalis*, it also appears to be related to *C. venustus*, having the same leg formula and the same reduced antennules. But *C. venustus* has rami with hairy inner margin, and is distinguishable from *C. viridis* with some difficulty.

How difficult is the separation of species in this group can be seen in perusal of American literature. Marsh in 1910 included all the American forms under one species—*C. viridis*, but in 1920 came to the conclusion that there are five valid American species—*viridis*, *americanus*, *parcus*, *brevispinosus* and *magnus*. His opinion was largely influenced by the work of Chambers (1912). Chambers found that, whereas *C. viridis* has 12 chromosomes, there are 10 in *C. americanus* and 6 in *C. parcus* (= *vernalis*). Marsh relied chiefly upon the shape of the receptaculum, but neither he nor Chambers took sufficiently into account characters such as the lengths of the furcal setæ and the structure of leg 4.

Much of the difficulty in dealing with this group is due to incomplete description. For instance, Ziegelmayer (1922) deals with the variability of *C. viridis*,

and constructs a number of curves from the measurements of 2000 individuals; but the characters chosen are mostly very difficult to measure accurately, and the most important are ignored. No useful conclusions can be drawn from the facts given. In the same way Chambers's work loses much of its value from the fact that he does not establish convincingly the forms with which he is dealing, and one cannot feel complete confidence in statements as to numbers of chromosomes.

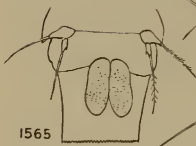
Cyclops viridis (Jurine).

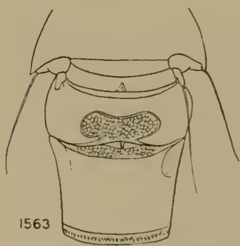
(Figs. 1563–1582.)

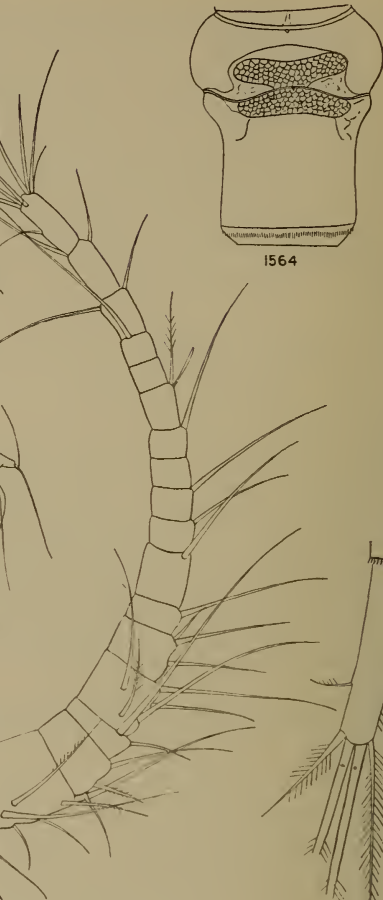
1820. *Monoculus quadricornis viridis*, Jurine, Hist. des Monocles, p. 46, fig.
1851. *Cyclops viridis*, Fischer, Bull. Soc. Moscou, XXIV, 2, p. 412, figs.
1857. *C. brevicornis*, Claus, Arch. Naturg. XXIII, 1, p. 32, figs.
1871. *C. clausi*, Heller, Ber. Ver. Innsb. I, p. 73, figs. (young).
1880. *C. gigas*, Brady, Mon. Brit. Cop. I, p. 105, figs.
1886. *C. viridis*, Vosseler, Jhft. Ver. Naturk. Württemb. XXII, p. 196, figs.
1892. ,, (part), Schmeil, Bibl. Zool. XI, p. 97, figs.
1892. ,, Brady, Trans. N. H. Soc. Northd. XI, p. 82, figs.
1895. *C. v. europæus*, Herrick, Rep. Geol. Surv. Minn. p. 90.
1901. *C. viridis*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 8, figs.
1913. *C. vulgaris*, Sars, Crust. Norway, VI, p. 40, figs.
1925. *C. teres*, Wilson, P. U. S. Mus. LXIV, p. 17.
1929. *Megacyclops viridis*, Kiefer, Tierreich, Lief. LIII, p. 53, figs.
1930. *M. v. acutulus*, Kiefer, Zool. Anz. LXXXIX, p. 322, fig.

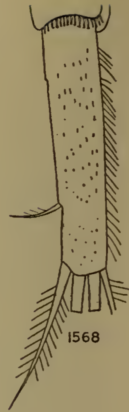
Female.—Length 1·5–3 mm.

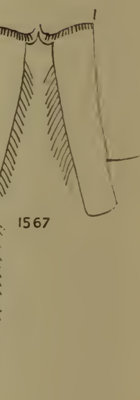
Body robust, greatest width of thorax exceeding one-third of body length (350–400°/$_{oo}$). Soms. 4 and 5 with lateral angles backwardly pointed, not turned outwards. Genital somite not greatly dilated, greatest width less than length. Receptaculum very variable in shape; anterior part generally with anterior margin concave; posterior part a narrow band. Abd. somites generally with posterior margins coarsely serrated, but surface not pitted. Furcal rami variable, generally about 4 times as long as wide, but occasionally as much as 5 or 6 times as long; inner margins profusely hairy; outer lateral seta inserted in distal third (about 75%); inner terminal seta longer than ramus, and about twice as long as outer.


1565


1563


1569
1564

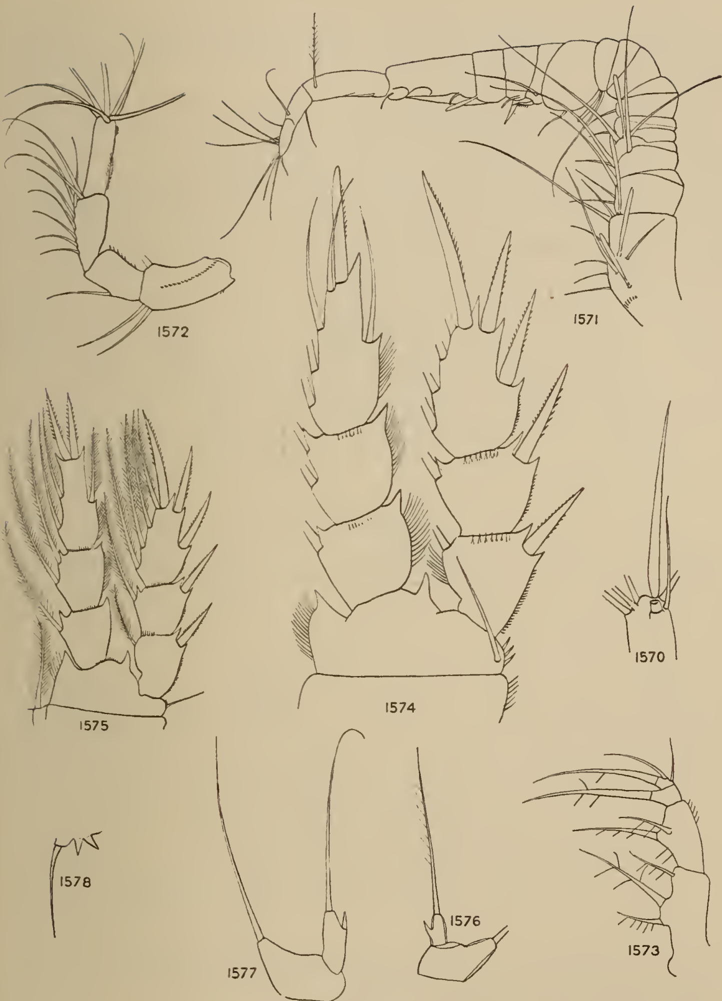

1568


1567


1566

Figs. 1563–1569.—*Cyclops viridis.*

Fig. 1563.—Genital somite and receptaculum.
Fig. 1564.—Genital somite.
Fig. 1565.—Genital somite, showing spermatophores.
Fig. 1566.—Furcal rami, female, dorsal.
Fig. 1567.—Furcal rami, ventral.
Fig. 1568.—Furcal ramus, with ventral spinules.
Fig. 1569.—Antennule, female.

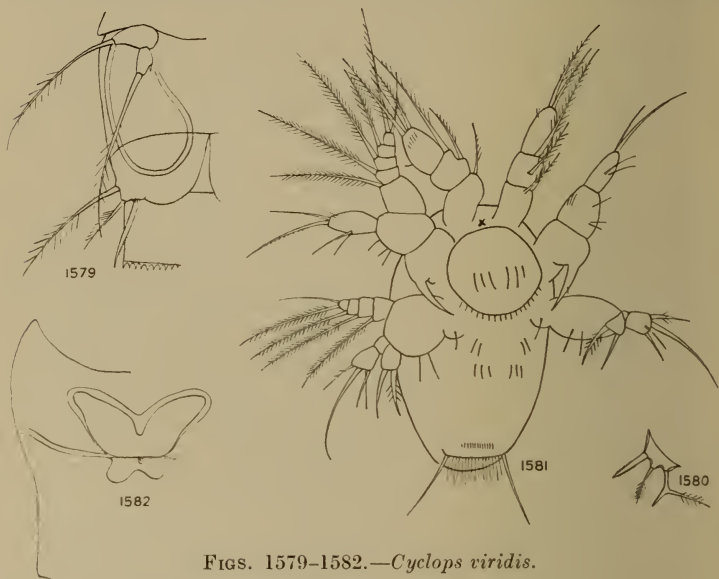


FIGS. 1570–1578.—*Cyclops viridis.*

FIG. 1570.—Antennule, seg. 17, showing æsthete.
FIG. 1571.—Antennule, male.
FIG. 1572.—Antenna.
FIG. 1573.—Maxillipede.
FIG. 1574.—Leg 3.
FIG. 1575.—Leg 4.
FIG. 1576.—Leg 5.
FIG. 1577.—Leg 5.
FIG. 1578.—Leg 6, female.

Antennule of 17 segments, reaching about to end of th. som. 1; terminal segments without hyaline membrane or hairs.

Legs with rami 3-segmented; spine-formula 2.3.3.3; endopod 3 of leg 4 more than twice as long as wide; terminal spines nearly equal, the inner one the longer, but always shorter than the segment; setæ not reaching



FIGS. 1579–1582.—*Cyclops viridis.*

FIG. 1579.—Legs 5 and 6, male.
FIG. 1580.—Leg 6, male, abnormal.
FIG. 1581.—Nauplius, stage 1.
FIG. 1582.—Receptaculum, abnormal. Oxford.

ends of terminal spines. Margins of exopod of leg 4 fringed with coarse spinules.

Leg 5 with basal segment very broad; seg. 2 small and rather slender; inner spine very small, inserted beyond middle, and either jointed to segment or fused with it.

Egg-sacs large, divergent.

Male.—Length 1·4–1·6 mm.

Antennule with very long æsthetes; segs. 16 and 17

sometimes not completely fused. Leg 6, inner spine strong, a little longer than middle seta; outer seta very long.

Abnormal Structures.

Some remarkable abnormalities in legs 5 and 6 have been described by Alverdes (1920) in the progeny of *C. viridis* derived from mating a male with abnormal leg 5 with a normal female. An additional seta or spine often appeared on one leg, but never on both. These abnormalities were not inherited, but there was a remarkably high frequency of abnormal structures in the progeny. Such abnormalities are exceedingly rare in natural conditions.

Distribution.

Generally distributed throughout the British Isles and northern Europe.

Outside Europe.

Central Asia (Sars); Turkestan (Daday); Transcaspia (Walter); Asia Minor (Spandl); Tibet (Daday); Siberia (Daday); Manchuria (Rylov); Baikal (Jaschnov); India (R. G.); Java (Kiefer).

Algeria and Tunisia (R. G., Roy and Gauthier); Azores (Barrois).

Abyssinia and Uganda (A. G. L.).

Bear Island (R. G.).

North America (Forbes, Marsh).

Florida (Marsh); Venezuela (Pearse); Argentine (Brian).

It is recorded from New Zealand by Thomson, but the identification is doubtful.

Bionomics.

Perhaps the commonest species, and found in all manner of waters. It is not found in plankton, but

Cyclops viridis. *Females.*

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
Norfolk, Ingham	2·10	..	130	4·8	62	81	385	515	143	2·08	104	100
,, ,,	2·30	360	100	3·7	74	68	365	478	152	2·26	112	88
,, Sutton Broad	2·95	355	132	6·3	75	78	421	445	143	2·80	101	95
,, ,,	2·00	375	110	4·9	74	..	..	..	..	2·77	105	85
,, East Ruston	2·40	..	129	4·2	80	91	435	640	200	2·60	113	84
,, Holt	1·55	405	97	3·1	75	77	494	640	200	2·30	185	88
,, Langmere	2·20	385	105	3·6	74	86	370	525	159	2·45	118	87
Suffolk, Herringfleet	2·17	395	101	3·5	72	77	..	..	138	2·60	105	82
Oxford	2·14	410	112	4·6	72	77	326	455	140	2·57	106	75
Bodmin	1·94	376	124	4·1	78	85	236	285	126	2·26	125	97
Wales, Bala Lake	2·12	378	118	3·6	74	80	440	565	189	2·36	118	88
Ireland, Knockley	2·37	370	88	4·2	72	61	360	530	144	2·41	103	68
Oxford	1·92	350	93	4·25	71	57	320	440	130	2·25	113	83
Tunisia	1·49	370	107	4·4	77	87	315	440	157	2·30	108	87
Palestine	1·22	410	94	3·2	75	77	425	605	196	2·05	118	91
,,	1·37	365	91	3·0	71	69	400	570	190	1·88	117	96

Males.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
Norfolk, Ingham	1·45	310	110	4·4	73	89	380	550	180	2·45	120	86
,, ,,	1·40	340	107	4·2	74	78	320	485	165	2·65	123	87
Oxford	1·59	315	150	3·8	68	69	300	430	158	2·64	140	95

prefers the weedy margins of lakes, or small pools. Occasionally taken on the bottom in deep lakes (*e.g.* Ennerdale), and has even been recorded from caves and wells (Graeter, Chappuis). De Lint has recorded a *C. v.* var. *pelagica* as common in Dutch plankton; but there is reason to believe that this is really *C. vernalis americanus.* Wolf states that it can survive drying in small pools, and it is to some extent tolerant of brackish water (Timm, 1903; Levander, 1900). Spandl (1923, p. 132) records a pelagic form from Asia Minor with 10-segmented antennules and 2-segmented legs, but this variety is not otherwise described. He also found individuals enclosed in "cocoons" made of a species of *Chætoceras*, but it is not clear if these corresponded to the resting cocoons of *C. bicuspidatus.*

It is found breeding throughout the year; but both Wolf (1905) and Walter (1922) distinguished 8 maxima, at intervals of 40–70 days.

Cyclops gigas, s. str., Claus.

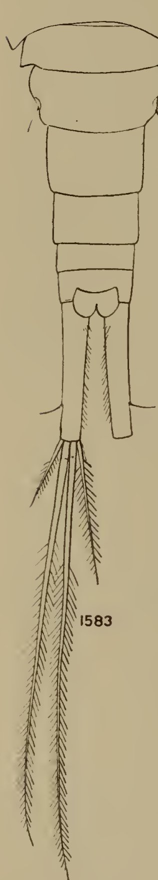
(Figs. 1583–1585.)

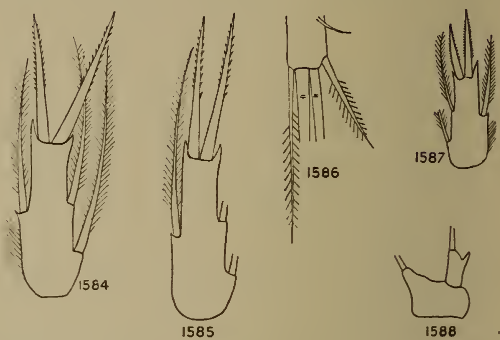
1857. *C. gigas*, Claus, Arch. Naturg. XXIII, 1, p. 207, figs.
1863. ,, Sars, Forh. Vid. Selsk. Christ. 1862, p. 35.
1882. *C. ingens*, Herrick, Rep. Geol. Surv. Minn. X, p. 228, figs.
1900. *C. gigas*, Lilljeborg, Bih. Svenska Akad. Handl. XXVI, afd. 4, no. 5, p. 4.
1902. ,, Lilljeborg, Svenska Akad. Handl. XXXV, p. 5, figs.
1913. ,, Sars, Crust. Norway, VI, p. 41, figs.
1927. ,, Kiefer, Arch. Balaton, I, p. 415, figs.
1929. ,, Kiefer, Tierreich, Lief. LIII, p. 53.

Female.—Length 2–3 mm.

General form as in *C. viridis.* Th. som. 5 not outturned. Gen. somite with distinct dorsal line of division; receptaculum as in *C. viridis.* Abd. somites slightly serrated; som. 5 with very fine spinules at base of rami. Furcal rami long and slender, 6 or 7 times as long as wide, and more than one-tenth of body length. Inner margin hairy; lateral seta inserted near end (about 72%). Inner terminal seta less than twice as long as outer one, and shorter, or not much longer, than rami; seta 3

very little longer than seta 2 and much less than half length of body. Antennule much shorter than th. som. 1. Legs with spine-formula 2.3.3.3. Exopod of leg 1 with outer margin fringed with hairs. In legs 2–4 exopod 1 with marginal spinules; exopod 2 with





FIGS. 1583–1585.—*Cyclops gigas.*

FIG. 1583.—Abdomen and th. som. 5, female. Wicken Fen.
FIG. 1584.—Leg 4, endopod 3. Wicken Fen.
FIG. 1585.—Leg 4, endopod 3. Upsala.

FIGS. 1586–1588.—*Cyclops magnus*, Marsh.

FIG. 1586.—End of furcal ramus.
FIG. 1587.—Leg 4, endopod 3.
FIG. 1588.—Leg 5.

hairs. Leg 4 with endopod 3 slender, more than $2\frac{1}{2}$ times as long as wide; terminal spines nearly equal, the inner a little the longer and very little shorter than the segment; setæ not reaching end of spines. Leg 5 as in *C. viridis*; seg. 2 slender, with inner spine near end

and jointed to segment. Egg-sacs very large, closely appressed to abdomen.

Specific Status of C. gigas.

Whether this is actually the same form as was described by Claus is by no means certain; but it has been re-described as such by Lilljeborg and Sars, and the name can be accepted.

Schmeil regarded *C. gigas* as a mere size-form of *C. viridis*, and, since his time, there has been much difference of opinion as to the validity of the species. Even when a difference has been acknowledged, it has been treated generally as a variety. Far too much stress has been laid upon size and length of furcal rami—two characters which, as Ekman pointed out (1915, p. 303), are without value. Sars and Lilljeborg have, however, established the existence of certain differences which seem to justify recognition of two distinct species. Mrázek also has maintained their distinction, chiefly on the ground of the very different breeding habit. *C. gigas* can be separated with certainty by the relatively shorter inner furcal seta, and generally by the greater slenderness of the exopod of leg 4 and its spines. As comparison of the measurements of the two forms will show, the latter differences are by no means always valid.

Whether *C. ingens*, Herrick, is actually a synonym of this species, as claimed by Sars, seems very uncertain. *C. magnus*, Marsh, from Arctic Canada is regarded by Kiefer as doubtfully synonymous. It resembles *C. gigas* very closely in the proportional lengths of the furcal setæ, but differs in the form of the receptaculum, and also in the stouter endopod of leg 4 and the much shorter terminal spines (Figs. 1586–1588).

Distribution.

Owing to the great uncertainty in identification of the species it is impossible to give any satisfactory statement of its distribution.

Cyclops gigas.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
Bear Island . . .	2·9	330	110	5·6	73	68	325	360	115	2·7	100	89
,, . . .	2·84	380	127	5·4	73	67	350	388	123	2·75	110	83
,, . . .	3·0	350	133	6·4	74	70	350	..	110	2·62	109	84
,, . . .	2·97	335	131	5·75	72	64	..	..	110	2·82	117	91
Upsala (Sweden), ♀ . .	2·82	368	117	5·8	72	71	343	372	129	2·65	105	90
,, ♂ . .	1·95	360	118	4·88	73	97	..	..	170	2·38	100	100
Wicken Fen . . .	3·0	362	140	6·8	73	57	290	310	100	2·74	100	84

C. g. latipes.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
Marlborough, ♀* . .	1·93	362	126	6·2	68	77	336	405	104	2·0	114	92
,, ♂ . . .	1·68	305	119	6·0	67	60	..	..	103	2·13	113	90
Oxford (Bayworth), ♀. .	2·00	345	120	5·1	67	76	340	440	105	1·82	116	87
,, ,, ♂ .	1·53	295	104	4·56	68	85	320	405	130	1·85	114	94
Oxford (Cothill), ♀ . .	1·85	390	130	5·75	74	86	420	520	130	2·1	113	88
,, ,, ♂ . .	1·46	350	130	5·55	75	107	430	590	165	2·3	113	100
France . . .	2·6	370	110	..	70	80	..	..	112	1·96	107	114

* Average.

In Britain it is only definitely known from Wicken Fen (Lowndes). I have never met with it myself.

Sweden (Lilljeborg); Norway (Sars); Iceland (Sars); Bear Island (Lilljeborg, R. G.), Bohemia (Mrázek); Hungary (Kiefer); France (Roy).

Bionomics.

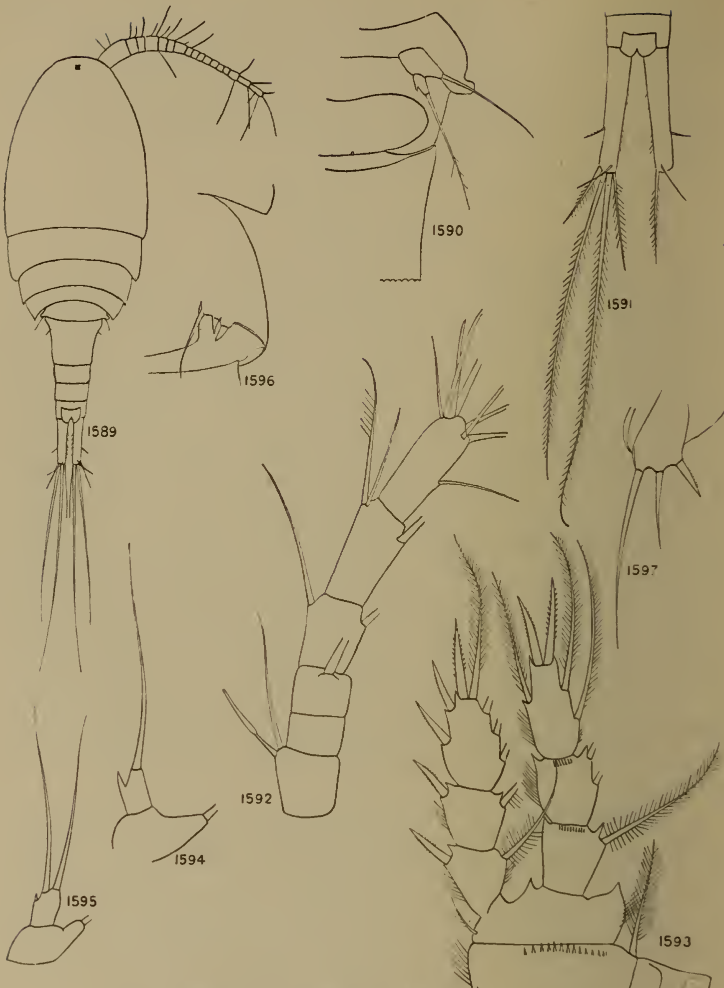
According to Mrázek (1913, p. 24) the species is monocyclic. Males are found in autumn and beginning of winter, and the females are fertilized in the last copepodid stage. The males then disappear, and the females alone are found through the winter. They moult after fertilization, and carry egg-sacs during winter. The young rapidly grow to the stage with 11-segmented antennules, and persist in this stage through summer. Further growth occurs in autumn till the last copepodid is reached, and this stage persists for some time, the animals becoming covered with epizoa and algæ. Adults are therefore only to be looked for during winter. Lilljeborg (1900, p. 5) lays special stress upon the difference in life-cycle between the two species. Mr. Lowndes has confirmed the observation of Mrázek that the copepodid stages do not mature during summer.

A characteristic of the species, according to Mrázek, is the frequency of androgyne abnormalities in the female antennule. About 4% of females show some trace of male secondary sexual characters. Possibly the partial separation of abd. soms. 1 and 2 is a manifestation of the same tendency to resemble the male.

Cyclops gigas latipes, Lowndes.

(Figs. 1589–1597.)

1927. *C. latipes*, Lowndes, Ann. Mag. Nat. Hist. (9), XIX, p. 266, figs.
1928. ,, Lowndes, Nat. Hist. Wicken Fen, IV, p. 336.



Figs. 1589–1597.—*Cyclops latipes.*

Fig. 1589.—Female, dorsal.
Fig. 1590.—Part of th. som. 5 and genital somite.
Fig. 1591.—Furcal rami.
Fig. 1592.—Part of antennule.
Fig. 1593.—Leg 4.
Fig. 1594.—Leg 5.
Fig. 1595.—Leg 5, abnormal.
Fig. 1596.—Leg 6, female, last copepodid.
Fig. 1597.—Leg 6, male.

Female.—Length 1·85–2·25 mm.

Closely resembling *C. gigas*. Th. som. 4 with rather acute lateral angle, slightly out-turned; th. som. 5 with outer angle constricted into a papilliform process directed outwards and forwards. Genital somite a little longer than wide, not much dilated anteriorly, and not divided. Receptaculum with anterior part concave in front. Furcal rami long and slender, slightly tapering towards end; inner margins less hairy than in *C. viridis* or *C. gigas*; length 5–6 times the width; lateral seta inserted at about distal third (67–75%); outer apical seta much more than half length of inner, which may be a little shorter or a little longer than the ramus. Leg 4 endopod 3 broader than in *C. gigas*, the length about twice, or less than twice, the width. Terminal spines nearly equal, the inner one nearly as long as the segment; setæ extending far beyond end of spines; outer margin of exopod fringed with hairs. Leg 5 with seg. 2 generally less slender than in *C. gigas*, the inner spine not jointed. A curious abnormality is shown in Fig. 1595. In this case there was a long additional terminal seta. If significance is allowed to these abnormalities this one would suggest a reversion to a primitive arrangement of 3 setæ or spines ("trifida").

Egg-sacs large, divergent.

Colour greyish, never green.

Mr. Lowndes (1932A) finds that a fertile cross cannot be effected between this form and *C. viridis*—a fact which is strong evidence for specific distinction. The differences between it and *C. gigas*, s. str., are small, but appear to be constant. The close relationship seems to be best expressed by regarding it as a subspecies of *C. gigas*.

A species very closely related is *C. donnaldsoni*, Chappuis, from a cave in North America. Kiefer has described a subspecies of it, *C. d. algericus*, from a spring in Algeria. The species differs from *C. g. latipes* in the shorter furcal rami, but agrees with it in the form of endopod of leg 4.

Distribution.

Britain: Wiltshire; Marlborough (A. G. L.).
Cambridge: Wicken Fen (A. G. L.).
Berkshire: Bayworth and Cothill (R. G.).
Cornwall: Bodmin (R. A. Todd).
Ireland: Kilbarrack (R. G).
France: La Flêche (Roy).

Probably many records of "*C. gigas*" really refer to this species.

Bionomics.

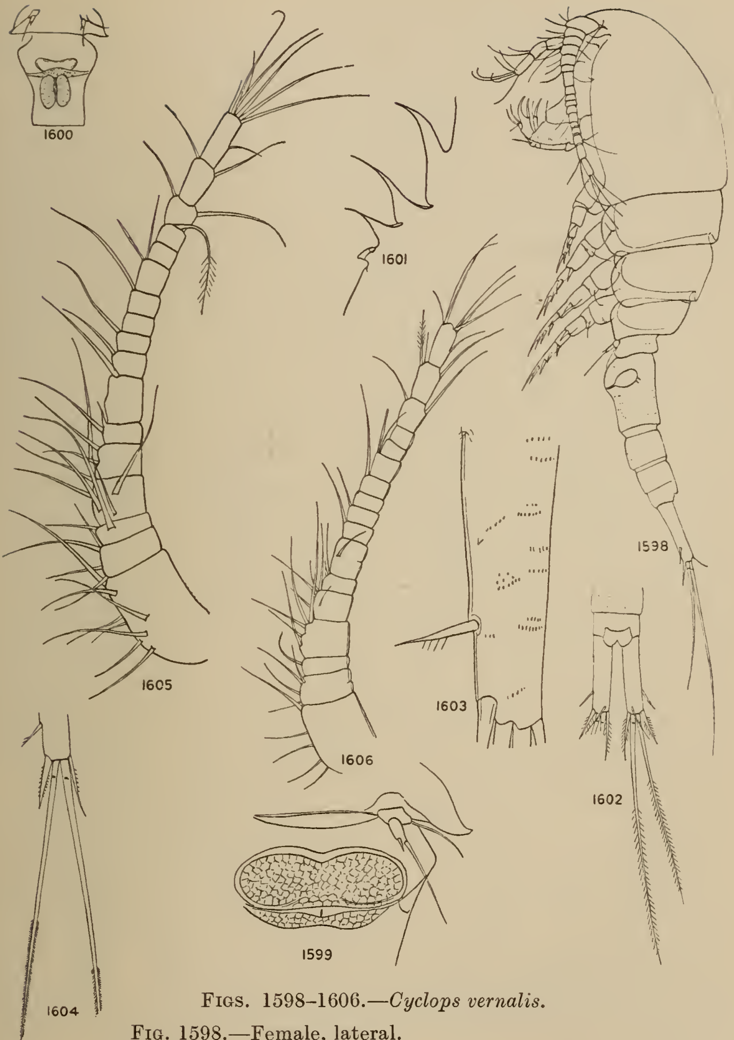
Mr. Lowndes states that *C. latipes* is common at all seasons in the neighbourhood of Marlborough, so that it apparently differs from *C. gigas* in its life-cycle. On the other hand, I have only found it myself in winter and spring. It is found near Oxford only in small puddles and ditches.

Mr. Lowndes gives its range of pH as 6·5–8·2.

Cyclops vernalis, Fischer.

(Figs. 1598–1615.)

1853. *C. vernalis*, Fischer, Bull. Soc. Moscou, XXVI, 1, p. 90, figs.
1863. *C. lucidulus* and *C. robustus*, Sars, Forh. Vid. Selsk. Christ. p. 245.
? 1863. *C. elongatus*, Claus, Freileb. Cop. p. 97, figs.
1882. *C. parcus*, Herrick, Rep. Geol. Surv. Minn. X, p. 229, figs.
1884. *C. brevispinosus*, Herrick, *ibid.*, XII, p. 148, figs.
1892. *C. elongatus*, Brady, Trans. N. H. Soc. Northd. XI, p. 70, figs.
1892. *C. vernalis*, Schmeil, Bibl. Zool. XI, p. 88, figs.
1893. *C. v.* var. *aculeata*, Mrázek, SB. Böhm. Ges. no. 8, p. 30, fig.
1897. *C. vernalis*, Schmeil, Bibl. Zool. Heft 21, p. 150.
1901. ,, and *C. robustus*, Lilljeborg, Svenska Akad. Handl. XXXV, pp. 17, 19, figs.
1910. *C. viridis* var. *brevispinosus*; *C. v.* var. *parcus*, Marsh, Trans. Wisc. Acad. XVI, pp. 1075, 1076, figs.
1913. *C. lucidulus*; *C. robustus*, Sars, Crust. Norway, VI, pp. 44, 45, figs.
1914. *C. vernalis* var. *ornatus*, Jungmayer, Math. Term. Közlem, XXXIII, p. 68, figs.
1924. *C. robustus*, Kiefer, Zool. Anz. LXI, p. 298, figs.
1926. *C. vernalis* vars. *ambigua*, *infesta*, *aculeata*; *C. robustus* vars. *setiger*, *saxonica*, *aphanes*, *armata*, Thallwitz, Arch. Hydrob. XVII, p. 366, figs.
1926. *C. v.* forma *aculeata*; *C. v.* var. *tetracantha*; *C. v.* var. *tetracantha* forma *robusta*, Kiefer, *ibid.*, XVI, p. 504.
1926. *C. lucidulus*, *C. robustus*, Lowndes, Rep. Marlb. Soc. no. 74, pp. 82, 97, figs.
1928. *C. vernalis*, Lowndes, Int. Rev. Hydrob. XXI, p. 171, figs.
1929. *Acanthocyclops vernalis*; *A. robustus*, Kiefer, Tierreich, Lief. LIII, p. 54.



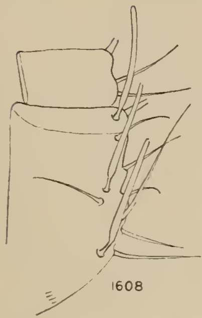
FIGS. 1598-1606.—*Cyclops vernalis.*

FIG. 1598.—Female, lateral.
FIG. 1599.—Receptaculum.
FIG. 1600.—Genital somite, showing spermatophores.
FIG. 1601.—Th. soms. 4 and 5, showing shape of angles.
FIG. 1602.—Furcal rami.
FIG. 1603.—Part of ramus, showing spinules on surface.
FIG. 1604.—Part of ramus, *robustus*-form.
FIG. 1605.—Antennule, female.
FIG. 1606.—Antennule, segs. 2 and 7 partly divided.

Female.—Length 1·0–1·8 mm.

Body rather robust; greatest width of thorax more than one-third of total length. Th. som. 4 laterally expanded with a slightly recurved point; th. som. 5 with a similarly recurved pointed expansion. Genital somite broad in front, the greatest width about equal to length. Abdominal somites, or whole body, sometimes with cuticle pitted, and with posterior hyaline membrane delicately serrated; but this serration usually confined to som. 4. Furcal rami very slightly divergent, very variable in length; length usually about 6 times the width and about 130°/$_{00}$ of body length; rarely exceeding 6 times width, but may be less than 5 times. Outer margin with very slight anterior notch; lateral seta near end (75%); inner margin without hairs; outer and inner terminal setæ short, the latter usually about half length of ramus and not greatly longer than outer seta; the latter either slender or spine-like. Setæ 2 and 3 very long, the inner much longer than outer; typically they are clothed with slender hairs on either side, but they may be armed in their distal part with very closely placed short stiff bristles. In such cases there may also be fine hairs on proximal half. Receptaculum rather variable; generally with anterior part stretching right across somite, elliptical, with anterior margin evenly arched; occasionally with median indentation; generally no hyaline margin is visible; posterior part reduced to a very narrow band or not visible. Antennule of 17 segments, generally shorter than som. 1. Occasionally seg. 7 is divided, and it commonly shows traces of incipient division. Fig. 1606 shows an antennule in which seg. 2 also is partly divided. Swimming-legs with rami 3-segmented; exopod 3 with spine-formula 2.3.3.3 or 3.4.4.4. There is a strong tendency to modification of the setæ of both endopod and exopod into spines. This tendency shows itself first in the distal setæ, and rarely affects those of proximal segments; every transition in modification is seen, from a seta with delicate hairs proximally and


1607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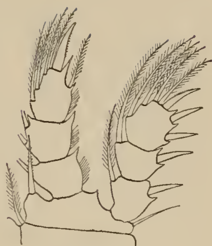
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1610


1611


1615


1612


1613


1614

FIGS. 1607-1615.—*Cyclops vernalis.*

FIG. 1607.—Antennule, seg. 17.
FIG. 1608.—Antennule, male, segs. 1 and 2.
FIG. 1609.—Leg 1.
FIG. 1610.—Leg 2.
FIG. 1611.—Leg 4.
FIG. 1612.—Leg 4, *robustus*-form.
FIG. 1613.—Leg 5.
FIG. 1614.—Leg 5, abnormal. Jura.
FIG. 1615.—Legs 5 and 6, male.

short stiff hairs distally, to a definite stiff spine with denticulate margins. Leg 4 endopod 3 generally a little more than twice as long as wide, very rarely less than twice as long; terminal spines rarely exceeding three-quarters of length of exop. 3, generally the outer a little the longer of the two; outer lateral seta very commonly modified as a spine. Leg 5 with seg. 1 broad, with short slender seta; seg. 2 small and slender, with relatively short terminal seta and a small subapical spine.

Colour: Yellowish to reddish.

Egg-sacs not divergent, rather large, with 7–70 eggs.

Bionomics.

A very common species in ditches and small pools, but never in lakes or other open waters. On the other hand, Marsh (1920) states that *C. brevispinosus* in America is a limnetic form (*cf. C. bicuspidatus*). It has been recorded from brackish water, and is tolerant of a wide range of pH (4·6–8·2, Lowndes, 1928). Brian records it in the Apennines up to 2800 metres.

It is to be found breeding throughout the year; but is most common in spring and autumn. Klausener states that, in the high Alps, it is dicyclic, not being found in summer.

Variation.

As the list of synonyms shows, a number of species and varieties related to *C. vernalis* have been described both in Europe and America. In the latest revision of the group (Kiefer, 1929) *C. vernalis* and *C. robustus* are treated as distinct species, so that it is necessary to justify uniting them. In my opinion absolute proof of their identity is given by Mr. Lowndes's breeding experiments (Lowndes, 1928). He found that the two species are fertile when crossed, and that typical *C. vernalis* forms may appear in the offspring of typical *C. robustus*. There was also great variability of the

Cyclops vernalis.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.			Leg formula.
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Outer % of inner spine.	Outer spine % of end. 3.	
Oxford, Cothill	1·24	370	129	6·0	70	57	265	380	77	2·27	100	62	3.4.4.4
Norfolk, Calthorpe	1·58	385	134	6·7	75	57	285	400	76	2·25	104	62	,,
,, Newton	1·30	337	112	5·6	75	45	284	445	88	2·27	106	70	,,
,, ,,	1·23	365	104	4·65	74	57	309	445	81	1·8	100	67	,,
Axminster	1·27	361	114	5·0	73	47	324	465	80	2·0	118	69	3.4.4.4/2.3.3.3
,, ♂	0·86	370	122	4·25	71	58	325	510	98	2·3	97	82	2.3.3.3
Oxford	1·37	360	116	6·0	76	51	255	380	66	2·25	105	59	,,
Suffolk	2·17	395	101	3·5	72	43	..	..	78	2·6	98	80	,,

var. robustus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.			Leg formula.
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Outer % of inner spine.	Outer spine % of end. 3.	
Oxford	1·35	355	130	5·6	73	48	288	480	59	2·32	112	62	3.4.4.4
,, ♂	0·97	340	123	4·2	74	57	330	512	78	2·4	95	85	,,
Norfolk, East Ruston	1·36	366	132	5·7	77	55	268	455	68	2·42	132	65	,,
Hampshire	1·80	345	119	3·1	73	45	284	445	88	2·27	106	70	,,
Bodmin	1·10	364	137	4·7	77	54	273	465	64	1·88	93	78	,,

spine formula in the broods produced. I have myself reared 9 adult females from a typical *C. robustus*, all of which, though with the formula 3.4.4.4, had the setæ quite unmodified. Observation in the field confirms this conclusion. The spine formula, which Kiefer relies upon absolutely in distinguishing the species, is most variable, and Sars himself described a variety of *vernalis* with the formula 3.4.4.4. I myself find this more common than 2.3.3.3. It is by no means unusual to find both in the same population, and asymmetry in individuals. Lowndes offers sufficient evidence of this variability. The only distinction remaining between the two forms is the modification in *C. robustus* of one or more setæ on legs 2–4 and the rami. Every possible transitional form can be found between those with no setæ modified, and an extreme form with nearly all the setæ of the legs changed into spines, while the setæ of the rami may both have fringing hairs, or both with short bristles, or they may be unlike. Thallwitz (1926) has described seven named varieties, some of which were associated in the same pool, based on modifications of one or more setæ; but these are merely fluctuations which can easily be found anywhere or within a single brood.

Distribution.

Common throughout Europe.

Central Asia (Sars); Turkestan (Daday); Manchuria (Rylov).

China (Daday).

Kolguev (Zykoff); Greenland, Iceland (Haberbosch).

Canada and North America (widely distributed).

Canaries (Richard); Kerguelen Is. (Ruhe).

Ceylon (Poppe and Mrázek).

S. America (Daday, Mrázek); Peru (Kiefer).

Algeria (Roy and Gauthier).

Cyclops vernalis americanus, Marsh.

(Figs. 1616–1625.)

? 1863. *C. elongatus*, Claus, Freileb. Cop. p. 97, figs.
1893. *C. americanus*, Marsh, Trans. Wisc. Acad. IX, p. 202, figs.
1895. *C. viridis americanus*, Herrick and Turner, Geol. Surv. Minn. Zool. ser. II, p. 91, figs.
1897. ,, var. *insectus*, E. B. Forbes, Bull. Illin. Lab. V, p. 41.
1898. *C. brevicornis*, Scourfield, Essex Nat. X, p. 325.
1903. ,, Scourfield, J. Quekett Micr. Cl. (2), VIII, p. 535.
1910. *C. viridis* var. *americanus*, Marsh, Trans. Wisc. Acad. XVI, p. 1076.
1917. ,, var. *dives*, Jungmayer, Math. Term. Közl., XXXIII, p. 61, figs.
1920. *C. americanus*, Marsh, Rep. Canad. Arct. Exp. p. 9J.
1926. ,, Lowndes, Rep. Marlb. Soc. no. 74, p. 89, figs.
1926. ,, Lowndes, Ann. Mag. Nat. Hist. (9), XVII, p. 616, figs.
1928. ,, Lowndes, Int. Rev. Hydrob. XIX, p. 12, figs.

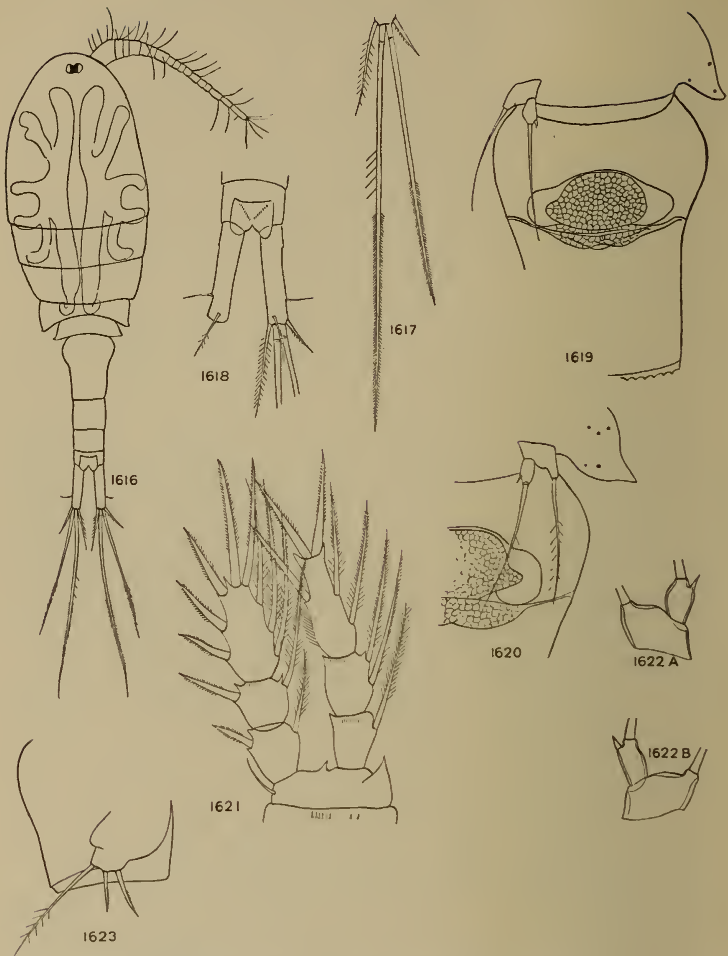
Female.—Length 1·3–1·5 mm.

General form as in *vernalis*, but more slender, and with th. soms. 4 and 5 with lateral processes blunt and usually not at all recurved. Cuticle without pit-like markings. Receptaculum as in *C. vernalis*, but with a broad hyaline border round anterior part. Abdominal somites very slightly serrated. Furcal rami about six times as long as wide and about 120°/₀₀ of total length; inner terminal seta about twice as long as outer, and nearly as long as ramus. Swimming-legs as in *C. vernalis*, with spine formula either 2.3.3.3 or 3.4.4.4. Leg 4 endopod 3 very slender, about $2\frac{3}{4}$ times as long as wide, and with terminal spines nearly as long as segment. Leg 5 as in *C. vernalis*. The two legs of one individual are shown in Fig. 1622 as examples of variation.

As in the case of *C. vernalis*, there is a tendency to modification of the setæ of the legs. Whereas Marsh describes the species as having no modified setæ, all English specimens which I have seen have both middle furcal setæ and some of the setæ of the legs modified.

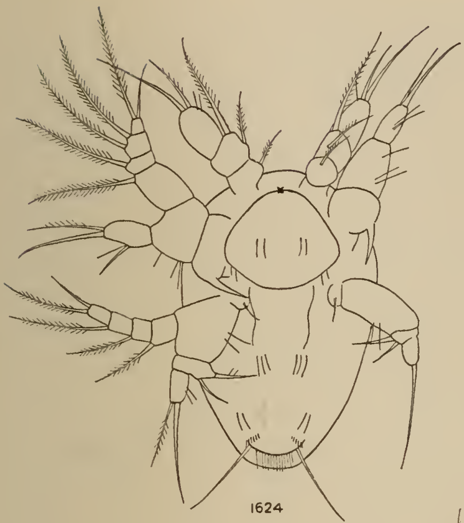
Colour: Colourless, except for blue pigment in walls of gut and in mouth region. Small blue spots in rostrum, labrum, appendages and abdomen. These spots are very characteristic of this form.

It is questionable whether the form described above should be regarded as a distinct species. Kiefer (1929)

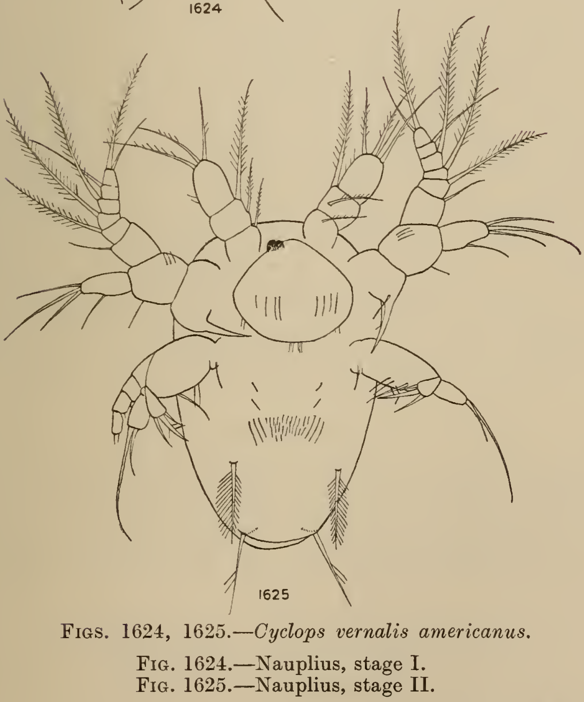


Figs. 1616–1625.—*Cyclops vernalis americanus.*

Fig. 1616.—Female, dorsal. Essex.
Fig. 1617.—Part of furcal ramus, showing feathering of setæ.
Fig. 1618.—Furcal rami.
Fig. 1619.—Genital somite and receptaculum. Wilston Reservoir.
Fig. 1620.—Genital somite and receptaculum. Leytonstone.
Fig. 1621.—Leg 4.
Figs. 1622a and b.—Leg 5 right and left of one specimen.
Fig. 1623.—Leg 6, male.



1624



1625

FIGS. 1624, 1625.—*Cyclops vernalis americanus.*

FIG. 1624.—Nauplius, stage I.
FIG. 1625.—Nauplius, stage II.

treats it as a synonym of *C. robustus*. That the British specimens are to be referred to *C. americanus* there can be no doubt, though they differ from the American form in exactly the same way as *C. vernalis* differs from *C. robustus*—that is to say, the setæ of legs and rami are more or less spiniform. Mr. Lowndes (1927) finds the spine formula is not constant, and may be 2.3.3.3 or 3.4.4.4 in the progeny of a single female. It differs from *C. vernalis* in the greater slenderness of body and limbs, and particularly in the form of the receptaculum. Generally there is marked difference in the form of th. som. 5, but specimens from Epping sent to me by Mr. Scourfield not only have the angles of this somite recurved, but also a receptaculum somewhat intermediate between the two forms. The difficulty in separating these closely allied forms is illustrated by the measurements of specimen 3 in the table. Taken at the same time as Nos. 1 and 2, it was at once picked out as being larger and clean, whereas all others were covered with algæ. It had all the characters of *C. vernalis* var. *robustus*, except for presence of blue pigment and a receptaculum like *C. v. americanus*. This particular individual could, therefore, be equally well placed in either of these specific units. It seems advisable to regard it as a subspecies of *C. vernalis*. Claus's figures and description of *C. elongatus* are very inadequate; but, if his figure of the animal is correct (Taf. XI, fig. 1), it must represent *C. americanus*.

Bionomics.

Nothing definite is known about seasonal appearance. According to Mr. Scourfield it is a limnetic form, and is taken in plankton in Dutch waters. I have only met with it myself in plankton in the Tring Reservoirs, Herts.

Distribution in Britain.

Warwickshire: Birmingham (A. G. L.).
Wiltshire: Marlborough (A. G. L.).

Cyclops vernalis americanus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Outer % of inner spine.	Outer spine % of end 3.
1. Tring Reservoir, ♀ . .	1·44	313	102	5·0	74	50	290	402	90	2·94	88	78
2. ,, ♀ . .	1·46	340	102	4·9	74	48	270	386	96	2·95	92	79
3. ,, ♀ . .	1·60	350	112	5·0	73	45	275	405	81	1·94	100	69
4. Essex (D. J. S.), ♀ . .	1·25	313	102	4·0	71	68	285	440	116	2·62	88	80
,, ,, ♂ . .	1·02	270	108	4·65	75	51	245	400	93	3·45	94	82

Devonshire: Dartmoor (A. G. L.).
Essex: Epping Forest (D. J. S.).
Hertfordshire: Tring Reservoirs (R. G.); Elstree Reservoir (D. J. S.).
Surrey: Richmond (D. J. S.).

DISTRIBUTION ABROAD.

Germany: (?) Cassel (Claus).
Holland (D. J. S., De Lint ?*).
North America: Widely distributed (Marsh).

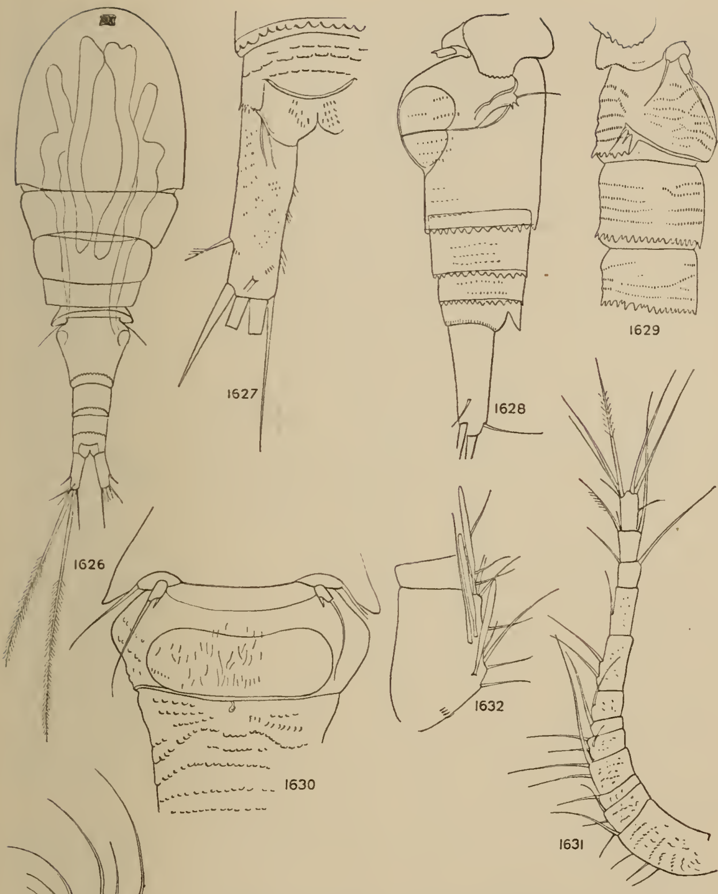
Cyclops venustus, Norman and Scott.
(Figs. 1626–1639.)

1906. *C. venustus,* Norman and Scott, Crust. of Devon, p. 189, figs.
1908. *C. crinitus,* E. Graeter, Zool. Anz. XXXIII, p. 45, figs.
1910. ,, E. Graeter, Arch. Hydrob. VI, p. 36, figs.
1922. ,, Chappuis, *ibid.*, XIV, p. 24, fig.
1923. *C. venustus,* Gurney, J. Linn. Soc. XXXV, p. 437.
1928. ,, Klie, Zool. Anz. LXXVIII, p. 62, figs.

Female.—Length 1·0–1·22 mm. (according to Graeter 2·1–2·3 mm.)

Body rather robust; greatest width more than one-third of total length. Th. soms. 4 and 5 not laterally produced or pointed; surface of cuticle of th. somites densely covered with minute irregular ridges; edge of som. 5 slightly crenulated. Abd. somites with posterior margins very coarsely and conspicuously serrated, dorsally and ventrally; surface marked with transverse ridges broken into a series of scale-like elevations. In some specimens these markings have the appearance of pits, but this is, as Klie points out, probably an illusion; in the genital somite the area of the receptaculum is also covered with faintly-marked ridges. Genital somite a little wider than long. Receptaculum with anterior part evenly arched, or with median concavity;

* Whether the form described by De Lint as *C. viridis* var. *pelagica* (1922, p. 80) is actually this form or not it is impossible to say. De Lint figures the receptaculum of *C. vernalis*. As she was dealing with a small limnetic form which was, apparently, distinguishable from *C. viridis* and *C. vernalis*, one can only presume that it was *C. americanus*.

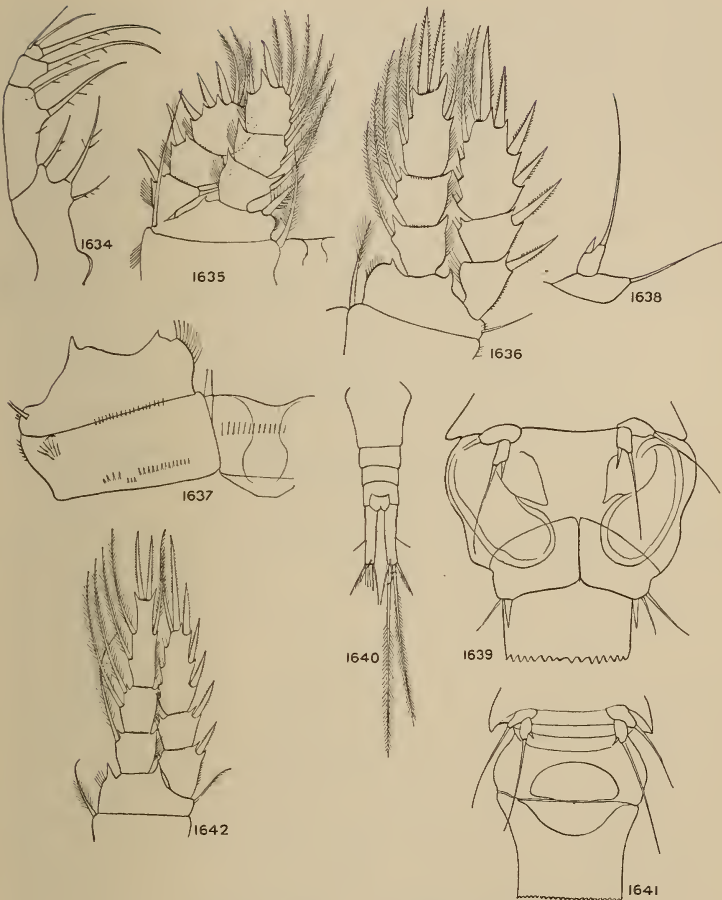


FIGS. 1626–1633.—*Cyclops venustus.*

FIG. 1626.—Female, dorsal (cuticular markings omitted).
FIG. 1627.—Furcal ramus, dorsal.
FIG. 1628.—Abdomen, lateral.
FIG. 1629.—Abdomen, lateral, last copepodid.
FIG. 1630.—Genital somite.
FIG. 1631.—Antennule, female.
FIG. 1632.—Antennule, male, segs. 1 and 2.
FIG. 1633.—Antenna.

posterior part rather narrow, the whole forming an oval organ. Anal operculum rather prominent. Anal area covered with minute hairs. Furcal rami short and broad, 3–4 times as long as wide, and about one-tenth of length of body ; inner margin with irregular bundles of fine hairs ; lateral seta inserted in distal third (about 70% of length) ; dorsal and ventral surface with minute granulation or prickles ; an incipient ridge on dorsal side at base. Inner furcal seta about as long as ramus, and twice as long as outer ; setæ 2 and 3 exceptionally long, the latter about as long as thorax. Antennule of 12 segments, shorter than th. som. 1 ; surface of segs. 1–9 with ridges on dorsal side. Antenna with cuticular markings on segs. 2–4 ; seg. 2 a little longer than seg. 3. Maxillipede long and slender ; seg. 3 about equal to seg. 2. Exopod 3 of legs 1–4 with spine-seta formula 3–5, 4–5, 4–5, 4–5. Leg 4, uniting lamella with transverse row of delicate hairs ; endopod 3 apparently rather variable, twice as long as wide or a little less than twice as long ; terminal spines nearly equal, the inner a little the longer ; inner spine shorter than segment. In some cases it is nearly as long (94%), but it may be much shorter (76%). Leg 5, seg. 1 very broad ; seg. 2 short, width about two-thirds of length ; inner spine short and stout, placed near end of segment. Egg-sacs closely apposed to body, with few eggs.

This species is easily recognized by its conspicuous cuticular markings, short furcal rami and 12-segmented antennule. Its identity with *C. crinitus* can hardly be doubted, though Graeter does not specially note the surface-markings, and these are not visible in a mounted specimen kindly sent me by Dr. Chappuis. In this specimen also the inner spine of leg 5 is very small, and the appendage closely resembles that of *C. viridis.* Chappuis regards *C. crinitus* as a variety of *C. viridis*, but it differs from the latter not only in the form of the receptaculum and reduced number of antennular segments, but also in the number of spines and setæ of the legs.



FIGS. 1634–1639.—*Cyclops venustus.*

FIG. 1634.—Maxillipede.
FIG. 1635.—Leg 1.
FIG. 1636.—Leg 4.
FIG. 1637.—Leg 4, coxa and uniting lamella.
FIG. 1638.—Leg 5.
FIG. 1639.—Genital somite, male.

FIGS. 1640–1642.—*Cyclops capillatus*, Sars.

FIG. 1640.—Abdomen and furcal rami, dorsal.
FIG. 1641.—Genital somite and leg 5.
FIG. 1642.—Leg 4.

Cyclops venustus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	P. 4. R.l. 3. L. : w.	Outer % of inner spine.	Inner spine % of end. 3.
Devonshire . . .	1·16	395	102	3·15	75	51	485	690	103	2·1	94	94
Bog of Allen . .	1·11	385	94	3·65	70	54	440	570	99	1·88	93	76
Floutern Pass . .	1·22	355	101	4·0	67	48·5	423	690	90	1·85	100	79
,, ♂ . .	·97	370	109	3·35	70	51	410	670	113	2·2	92	85
Bodmin . . .	1·04	400	100	3·27	73	62	463	690	100	1·62	104	70
,, ♂ . . .	·85	375	118	3·75	68	63	410	690	106	2·2	92	57

C. sensitivus.

Ringwood . . .	·72	402	84	2·5	60	84	390	610	180	2·0	63	90

C. capillatus, Sars, agrees with *C. venustus* in antennule, leg 5 and leg formula ; but it differs markedly from it in the form and arming of the furcal rami (see Fig. 1640). Apparently the most nearly related species is *C. phreaticus*,* Chappuis, which differs from it only in the absence of cuticular markings and of hairs from the rami. The leg-formula is not known.

Distribution.

England : Devonshire : Exmoor and Dartmoor (D. J. S., R. G.).
Cornwall : near Bodmin (R. G.).
Lancashire : Barrow-in-Furness (R. G.).
Cumberland : Floutern Pass ; Wasdale (R. G.).
Isle of Man (D. J. S.).
Yorkshire : Wensleydale (D. J. S.).
Ireland : Bog of Allen (R. G.).
Switzerland : Höll-Loch in Muotatal (Graeter) ; wells at Basel (Chappuis).
Germany : Wollingster See near Geestemünde (Klie).

Bionomics.

In this country I have found this species on several occasions, always in Sphagnum, and associated with the fauna characteristic of Sphagnum pools (*e.g. Acantholeberis*) ; but it is rare, and has not been met with anywhere in Scotland, where sphagnum pools are so abundant. Klie has taken it in a lake with sandy bottom and a vegetation including *Lobelia* and *Isoetes*, but not in association with Sphagnum. In acute contrast to these habitats is its occurrence in a cave and in wells, in both cases apparently in limestone districts.

Cyclops sensitivus, Graeter and Chappuis.
(Figs. 1643–1654.)

1914. *C. sensitivus*, Graeter and Chappuis, Zool. Anz. XLIII, p. 507, figs.
1922. ,, Chappuis, Arch. Hydrob. XIV, p. 35.

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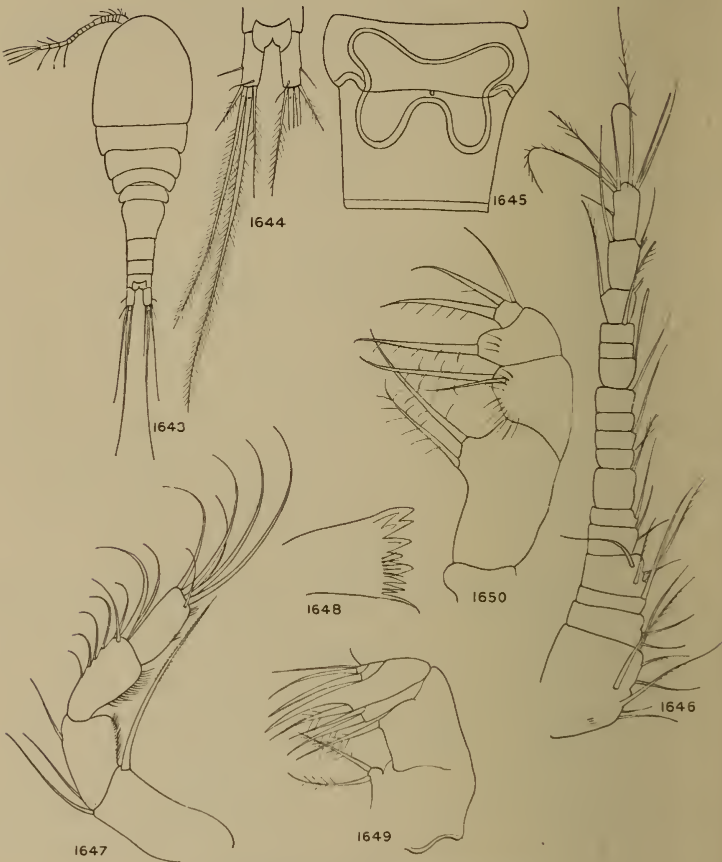
* Another very similar species is *C. stammeri*, Kiefer, which is hardly distinguishable from *C. phreaticus*.

Female.—Length ·72 mm.

Genital somite large, wider than long; receptaculum of unique form, butterfly-shaped. Furcal rami 2·5

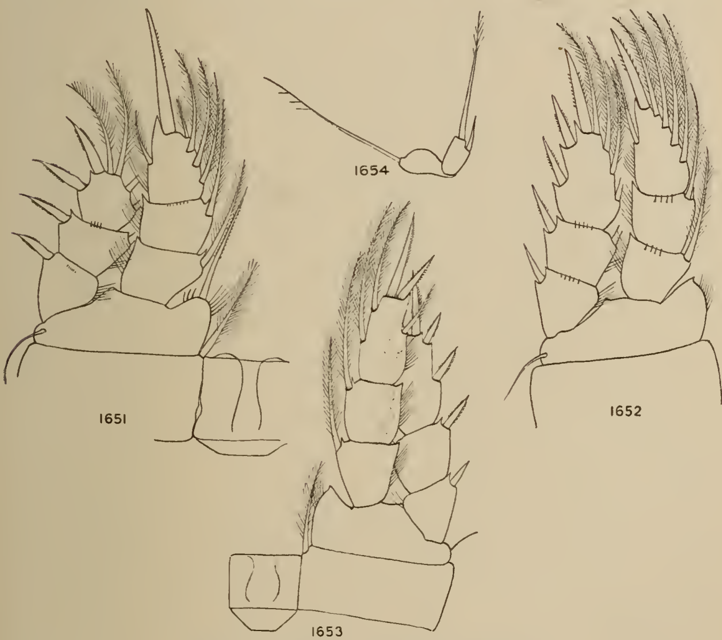


FIGS. 1643–1650.—*Cyclops sensitivus.*

FIG. 1643.—Female, dorsal.
FIG. 1644.—Furcal rami, dorsal.
FIG. 1645.—Receptaculum.
FIG. 1646.—Antennule, female.
FIG. 1647.—Antenna.
FIG. 1648.—Mandible.
FIG. 1649.—Maxilla.
FIG. 1650.—Maxillipede.

times as long as wide; lateral seta inserted beyond middle (60%); inner apical seta more than twice as long as outer, which is as long as ramus; seta 3 nearly

two-thirds length of body. Antennule of 17 segments, shorter than cephalothorax; æsthete of seg. 12 unusually long, reaching to end of seg. 15; sensory hair on seg. 16 reaching to end of seg. 17. Antenna with seg. 4 shorter than seg. 3; segs. 2 and 3 with stiff hairs on outer edge. Maxillule with 3 setæ on middle outer lobe of palp, of equal length. Maxilla and maxillipede



FIGS. 1651–1654.—*Cyclops sensitivus.*

FIG. 1651.—Leg 1.
FIG. 1652.—Leg 2.
FIG. 1654.—Leg 3.
FIG. 1654.—Leg 5.

of normal form. Legs with rami 3-segmented; uniting lamella straight and smooth; leg formula 2.3.3.3. Segments of all legs unusually stout; exopod 1 without inner seta; endopod 2 with one seta only. Leg 1 with inner seta on basis reaching beyond endopod 2; endopod 3 with terminal spine very large, longer than segment, but terminal seta very small, about one-third length of spine. Leg 4, endopod 3 twice as long as wide; inner

apical spine longer than outer (1·6 : 1), and shorter than segment. Leg 5 2-segmented; seg. 1 transversely elongated; seg. 2 less than twice as long as wide, with inner spine about as long as segment and seated very near end. Leg 6 represented by a long seta and a short spine. Egg-sacs long, divergent, with many eggs.

Colourless.

Male.—Unknown.

Distribution.

Taken by Chappuis in 1910 in six springs in the neighbourhood of Basle. It has not, so far as I know, been seen since, in spite of intensive search of underground waters by Chappuis and others. Chappuis notes that it was generally associated with *C. fimbriatus.*

I have taken a few specimens (all females) from wells at Ringwood (New Forest) in company with *Asellus cavaticus*, *Niphargus* sp., *Cyclops languidus*, *C. languidoides* and *C. agilis*. The wells are said to be comparatively shallow and apparently dug in the Bagshot sand (Eocene).

This species is placed by Kiefer in his subgenus *Acanthocyclops*—the "*vernalis group*"—and there seems to be no reason to object to this position. On the other hand, it has certain peculiarities which mark it off very distinctly from all other species with fully developed antennules and legs. Apart from the remarkable length of the æsthete on the antennule, and the peculiar form of the receptaculum, it is the only species except *C. demetiensis* in which exopod 1 has no inner seta on any leg. Only in the *varicans*-group and in *C. gracilis* there is no seta on leg 4. It is also remarkable for having one seta only on endopod 2 in all legs. There are a few cases in which there is only one in one or more legs—*C. languidus*, *abyssicola*, *nanus* (leg 3), *C. affinis* (leg 4).

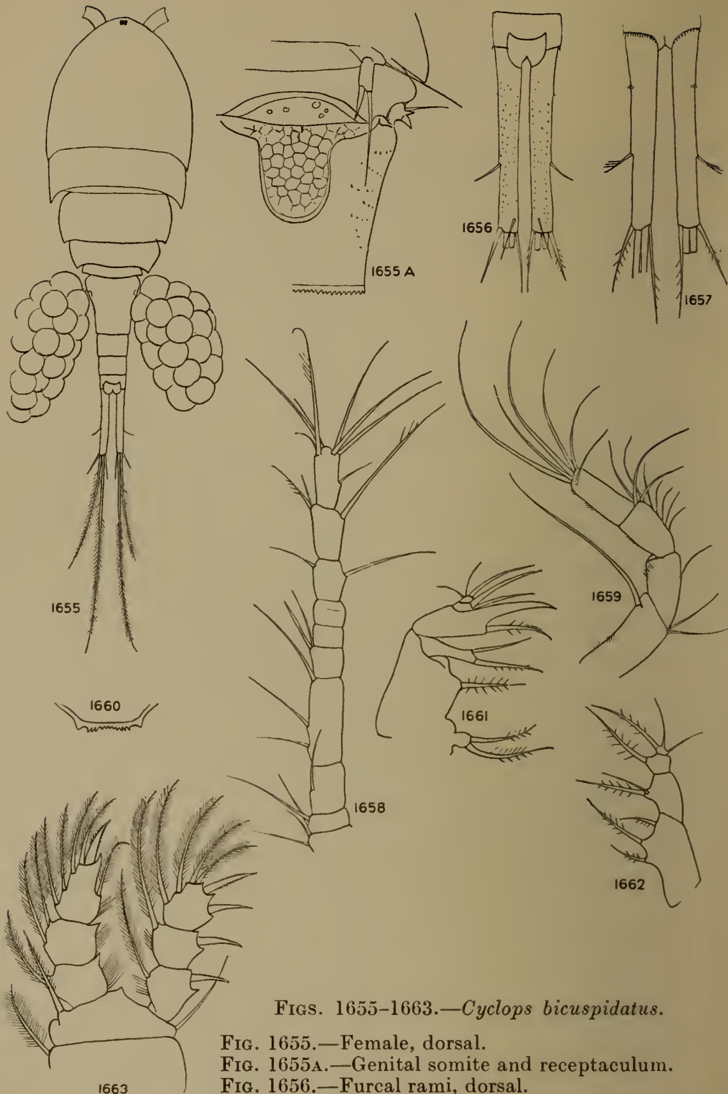
Cyclops bicuspidatus, Claus.

(Figs. 1655–1671.)

1857. *C. bicuspidatus*, Claus, Arch. Naturg. XXIII, 1, p. 209, figs.
1863. *C. pulchellus*, Sars, Forh. Vid. Selsk. Christ. 1862, p. 246.
1875. *C. bicuspidatus*, Hoek, Tijds. Ned. Dierk. Ver. III, p. 17, figs.
1882. *C. entzi*, *C. roseus*, Daday, Orv. Termés. Ert. VII, pp. 220, 222.
1892. *C. thomasi*, Brady, Trans. N. H. Soc. Northd. XI, p. 80, figs.
1892. *C. bicuspidatus*, Schmeil, Bibl. Zool. IV, Heft 11, p. 75, figs.
1901. ,, Lilljeborg, Svenska Akad. Handl. XXXV, p. 11, figs.
1913. *C. pulchellus*, Sars, Crust. Norway, VI, p. 47, figs.
1926. *C. b.* var. *synarthrus*, Lowndes, Rep. Marlb. Soc. no. 74, p. 88.
1929. *C. bicuspidatus*, Kiefer, Tierreich, Lief. LIII, p. 58.

Female.—Length ·95–1·57 mm.

Width of cephalothorax more than one-third length of body; th. soms. 4 and 5 with lateral angles slightly produced backwards and pointed. Cuticle of whole body, including rami and antennules, generally covered with minute pits. Receptaculum with posterior part large, reaching back about to middle of somite; anterior part narrow, generally not containing sperms. Furcal rami long and narrow, parallel; length generally about 6 times the width, and from 120 to 170°/₀₀ of body. Lateral seta inserted a little behind middle (60–68%); a small notch in anterior third; inner margin without hairs; inner terminal seta very short, generally only slightly longer than outer seta; seta 3 very long, generally nearly half length of body, and much longer than seta 2. Antennule of 17 segments reaching about to end of cephalothorax; seg. 12 with large æsthete. Legs with rami 3-segmented; spine formula 2.3.3.3. Leg 1 with apical spine very stout; inner seta of basipod reaching nearly to end of endopod 2. Leg 4 with endopod 3 from 2 to 3 times as long as wide, variable; inner apical spine shorter than outer. The relation between these two spines is very variable, even within the same population; they may be nearly equal, or the outer spine as much as twice the length of the inner one. Outer spine generally shorter than seg. 3, but occasionally longer; outer seta not reaching to end



FIGS. 1655–1663.—*Cyclops bicuspidatus.*

FIG. 1655.—Female, dorsal.
FIG. 1655A.—Genital somite and receptaculum.
FIG. 1656.—Furcal rami, dorsal.
FIG. 1657.—Furcal rami, ventral.
FIG. 1658.—Antennule, seg. 8 undivided (*odessanus* form).
FIG. 1659.—Antenna.
FIG. 1660.—Upper lip.
FIG. 1661.—Maxilla.
FIG. 1662.—Maxillipede.
FIG. 1663.—Leg 1.

of outer spine. Leg 5, seg. 1 about as wide as long; seg. 2 slender, with inner spine inserted nearly at apex. Inner spine about as long as seg. 2. Egg-sacs large, generally divergent.

Colour: Variable, commonly whitish or pink, often yellow.

Male.—Length about 1 mm., smaller than female.

Furcal rami as long as in female, and structure of legs the same. Antennule with æsthetes of seg. 1 rather long and slender (Fig. 1669). Leg 6 with strong inner spine; middle seta as long as spine; outer seta nearly twice as long.

Distribution.

Very common throughout Europe, and widely distributed in Britain. Outside Europe it is recorded from Canada (Willey), United States (Marsh, etc.*), Turkestan (Daday), Central Asia (Sars, Daday), Japan (Smirnov).

Bionomics.

In this country *C. bicuspidatus* is confined to small shallow pools and ditches, particularly those containing much decaying vegetable matter. I have taken it at all times of the year; but most often in spring and autumn. As Wolf (1905) has shown, it inhabits temporary pools, and reappears immediately after they are filled with rain, being evidently able to survive in mud. I have once known it to appear from dried mud in an aquarium. Brehm records finding it in the small pools formed in his own footprints in spongy woodland soil, showing capability of living actually in wet soil. It is tolerant of a very wide range of conditions, being recorded from underground waters and waters of high salinity.

* Records from the United States generally refer to *C. b. thomasi* according to Kiefer, but E. B. Forbes states that he has seen specimens agreeing with Schmeil's description.

Variation.

As noted above, there is much individual variation in the furcal rami and in leg 4. Vosseler (1886, p. 194) has noted that, in some individuals of *C. b. lubbocki*, not only was there suppression of segmentation in the antennule, but also in the legs, the rami being 2-segmented. Lowndes has found a similar form, but with normal antennules, common in Savernake Forest, in sphagnum bog, and has named it *C. b.* var. *synarthrus*. Among a few specimens sent to me by Mr. Lowndes was one with quite normal legs, measurements of which are given in the table.

Früchtl (1920, p. 491) has described a peculiar variety with the antennules of 11 segments.

C. haueri, Kiefer (1931D, p. 592), which is founded on a single female taken from a pond at New Haven, U.S.A., does not appear to differ in any respect from *C. bicuspidatus* except that the outer apical spine of leg 4 is a trifle shorter than the inner. *C. charon*, Kiefer (1931E, p. 703), from underground waters in Italy, is also scarcely distinguishable from *C. bicuspidatus*. In this case, however, leg 4 endopod 3 is markedly more slender, and there is some difference in the receptaculum.

The following two forms may conveniently be regarded as subspecies :

Cyclops bicuspidatus lubbocki, Brady.

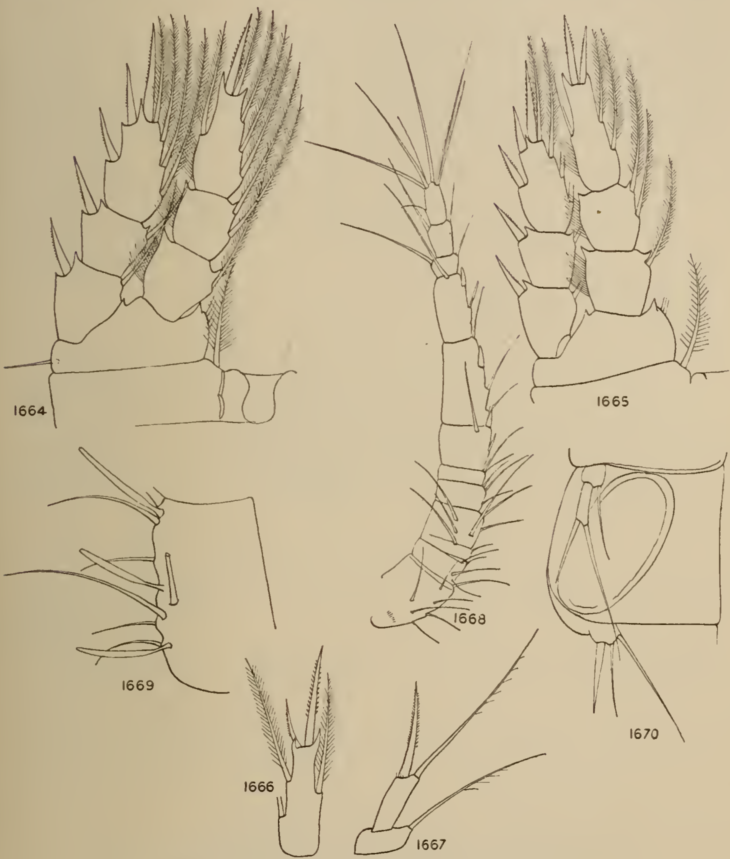
(Fig. 1658.)

1868. *C. lubbocki*, Brady, Trans. N. H. Soc. Northd. III, p. 127, figs.
1875. *C. odessanus*, Schmankewitsch, Sapiski Novoross. Obsch., III, p. 1, figs.
1878. *C. insignis*, Brady, Mon. Brit. Cop. I, p. 108, figs.
1880. *C. helgolandicus*, Rehberg, Zool. Anz. III, p. 301.
1892. *C. insignis*, Brady, Trans. N. H. Soc. Northd. XI, p. 83, figs.
1892. *C. lubbocki*, Canu, Trav. Lab. Zool. Wimereux, VI, p. 182, figs.
1913. *C. bicuspidatus*, var. Sars, Crust. Norway, VI, p. 47, figs.
1928. *C. b. odessanus*, Kiefer, Bull. Soc. Nat. Maroc. VIII, p. 99.
1929. *C. b. odessanus*, Kiefer, Tierreich, Lief. LIII, p. 59.

Female.—Length about 1 mm.

Furcal rami generally shorter than in typical form,

but frequently equally long and slender. Antennules with 14 segments; seg. 8 of the copepodid remaining



Figs. 1664–1670.—*Cyclops bicuspidatus.*

Fig. 1664.—Leg 3.
Fig. 1665.—Leg 4.
Fig. 1666.—Leg 4, endopod 3.
Fig. 1667.—Leg 5, endopod 3.
Fig. 1668.—Antennule, male, last copepodid.
Fig. 1669.—Antennule, male, seg. 1, showing æsthete.
Fig. 1670.—Legs 5 and 6, male.

undivided. Incipient division of the segment is, however, frequently found.

There is no other appreciable difference.

This form is quite common in brackish pools and ditches, but is not confined to brackish water. Schmeil and Lowndes note its occurrence in small fresh-water pools, and I have myself found it under the same conditions. Rylov (1928) found the typical form in brackish water at Enzeli (Persia), but *C. b. lubbocki* in fresh water in North Persia. Klie (1913, p. 5) notes

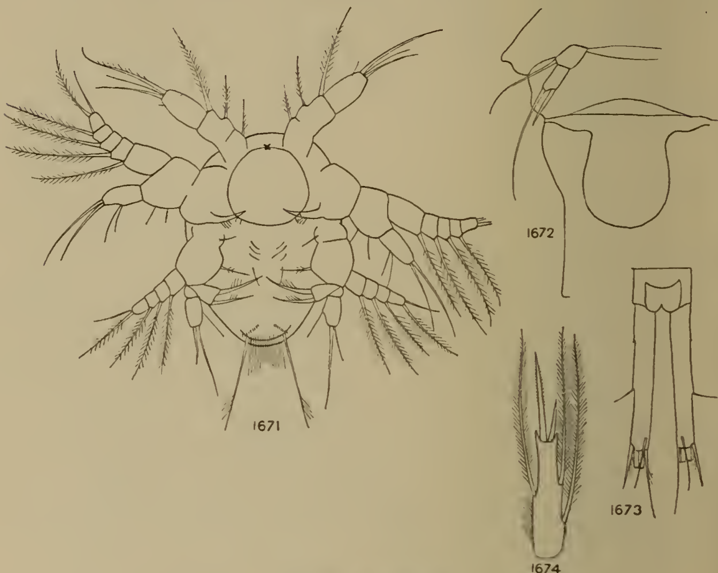


FIG. 1671.—*Cyclops bicuspidatus*, nauplius I.

FIGS. 1672–1674.—*Cyclops bicuspidatus thomasi.*

FIG. 1672.—Receptaculum, Lake Erie.
FIG. 1673.—Furcal rami. Lake Erie.
FIG. 1674.—Leg 4, endopod 3. Lake Erie.

that specimens found in the old harbour at Bremerhaven had normal antennules, whereas others from a brackish pool had 14 segments in antennule ; he concludes that the small size of the pool, rather than the salinity, determines the segmentation. Thienemann gives the highest salinity tolerated as 24·009 grm. per litre. Wolf (1905, p. 159) mentions a locality near Stuttgart where all individuals found on one occasion

were of typical form, while a month later all had antennules with 14 segments. This is evidently merely a "form" rather than a subspecies of *C. bicuspidatus*, but there are some advantages in giving it a subspecific name none the less. The suppression of segmentation of antennule must be a response to environment, but what factor influences it is unknown. It is certainly not solely salinity, neither can it be solely volume of habitat, since the typical form may be found in the smallest puddles. It seems a suitable object for experiment.

Distribution in Britain.

Wales: Pwllheli (Brady).
Ireland: Clare Island (D. J. S.).
Scotland: Dumbarton (Scott), Dalbeattie (R. G.).
England: Many records throughout England, but mainly in south and east.

Distribution Abroad.

Recorded from a number of localities throughout Europe.

North Africa: Algeria (R. G., Roy and Gauthier), Morocco (Kiefer).

Asia: Persia (R. G., Rylov); Mesopotamia (R. G.); Pamirs (Rylov).

Cyclops bicuspidatus thomasi, S. Forbes.

(Figs. 1672–1674.)

1882. *C. thomasi,* Forbes, Amer. Nat. XVI, p. 649, figs.
1897. *C. bicuspidatus,* E. B. Forbes, Bull. Ill. Lab. V, p. 44, figs.
1910. ,, Marsh, Trans. Wisc. Acad. XVI, p. 1078, figs.
1927. *C. thomasi,* Kiefer, Zool. Anz. LXXII, p. 264, figs.
1929. ,, Kiefer, Tierreich, Lief. LIII, p. 59.

Female.—Length about 1 mm.

Body more slender than in type form; th. som. 5 with papilliform process on either side. Antennules reaching beyond cephalothorax. Leg 4, endopod 3

Cyclops bicuspidatus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Outer % of inner spine.	Outer spine % of end. 3.
Ingham, Norfolk . .	1·50	380	160	6·5	69	60	353	545	80	2·92	200	97
Sutton ,, . . .	1·57	320	121	7·2	67	35	262	..	35	2·24	173	85
,, ,, . . .	1·31	380	149	6·8	64	51	344	510	57	2·26	192	100
Bodmin	1·35	347	151	6·5	68	45	370	562	67	2·12	176	100
Sutton, Norfolk . . .	1·29	372	131	7·8	63	62	286	465	59	2·8	129	67
Calthorpe ,, . . .	1·29	390	155	6·3	66	54	270	457	54	2·8	140	77
Marlborough, Wilts . .	1·30	353	138	6·8	68	58	326	470	62	2·3	180	94
,, ,, * . .	1·22	327	115	5·4	63	41	233	..	49	2·14	186	93
Sutton, Norfolk . . .	1·20	334	134	6·2	68	58	350	530	66	2·55	190	87
Ingham ,, . . .	1·11	387	162	7·0	60	54	287	465	77	2·83	132	70
Oxford	·99	365	151	5·8	66	55	297	465	65	2·92	140	86
Bodmin	·95	360	169	6·2	65	58	347	665	73	2·75	183	95
Norfolk, ♂	1·05	341	152	6·8	64	57	336	570	86	2·8	200	116

C. b. lubbocki.

Horsey, Norfolk . . .	1·0	320	149	9·3	64	50	230	370	75	2·92	150	80
Cothill, Oxford† . . .	1·12	347	140	6·0	63	47	228	365	80	2·93	126	65
Bayworth ,, † . . .	1·1	317	127	5·4	61	47	200	345	72	2·35	112	70

C. b. thomasi.

Lake Erie	1·07	316	158	6·4	59	47	..	365	70	3·6	185	78
,, ...	·87	287	144	7·2	54	35	206	390	75	3·9	205	73

* Var. *synarthrus*, Lowndes, but with normal legs.
† In fresh water.

more than 3 times as long as wide ; outer apical spine nearly twice as long as inner ; outer seta extending beyond outer spine. In all other respects as in *C. bicuspidatus.*

C. thomasi has been regarded by American authors as a synonym of *C. bicuspidatus*, but both Sars and Kiefer treat it as a distinct species. I have examined specimens from Lake Erie, and consider that it is a form sufficiently distinct to be regarded as a subspecies. Unlike *C. bicuspidatus* in Europe, *C. b. thomasi* is a common plankton form in the North American lakes, and it differs from the former in the character of greater slenderness of body and limbs which is generally associated with limnetic life.

Brady has recorded *C. thomasi* (1892) from Duddingston Loch, but his description is of typical *C. bicuspidatus.* The limnetic American form is not known from this country. It is no doubt this form which has been found by Birge and Juday (1908) to pass the summer in cysts on the lake bottom.

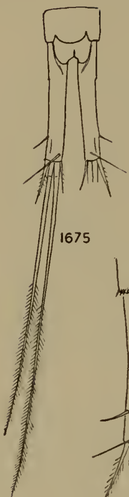
Cyclops bisetosus, Rehberg.

(Figs. 1675–1685.)

1863. *C. bicuspidatus,* Sars, Forh. Vid. Selsk. Christ. 1862, p. 247.
1880. *C. bisetosus,* Rehberg, Abh. Nat. Ver. Bremen, VI, p. 543.
1892. ,, Schmeil, Bibl. Zool. XI, p. 94, figs.
1901. ,, Lilljeborg, Svenska Akad. Handl. XXXV, p. 14, figs.
1913. ,, Sars, Crust. Norway, VI, p. 48, figs.
1929. ,, Kiefer, Tierreich, Lief. LIII, p. 60.

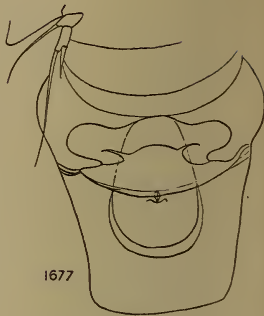
Female.—Length ·84–1·2 mm.

Body slightly flattened ; lateral angles of th. soms. 4 and 5 rounded and not produced. Cuticle generally very finely punctate, as in *C. bicuspidatus.* Genital somite about as long as broad, generally deeply indented at sides in position of genital opening ; receptaculum with broad hyaline border surrounding central part, and with a pair of small horn-like processes from the anterior, sperm-filled portion. Anal operculum rounded, rather prominent (Fig. 1676). Furcal rami



1675

1676



1677

1678

1680

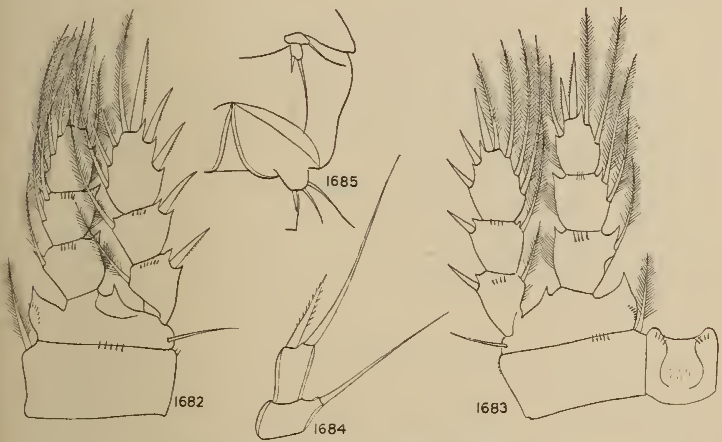
1681

1679

Figs. 1675–1681.—*Cyclops bisetosus.*

Fig. 1675.—Furcal rami, dorsal. Norfolk.
Fig. 1676.—Furcal rami, dorsal. Bodmin.
Fig. 1677.—Genital somite and receptaculum.
Fig. 1678.—Antennule.
Fig. 1679.—Antenna.
Fig. 1680.—Maxillipede.
Fig. 1681.—Leg 1.

parallel, 5–7 times as long as broad, and 120–145°/$_{\circ\circ}$ of body-length ; lateral seta inserted near end (77–83%) ; inner apical seta much shorter than ramus, and a little shorter than outer seta ; setæ 2 and 3 very long, the latter sometimes more than half length of body ; both setæ finely feathered. Antennule of 17 segments, extending very little beyond cephalothorax. Legs with rami 3-segmented, with spine formula 2.3.3.3 ; outer



FIGS. 1682–1685.—*Cyclops bisetosus.*

FIG. 1682.—Leg 3.
FIG. 1683.—Leg 4.
FIG. 1684.—Leg 5.
FIG. 1685.—Genital somite and leg 6, male.

margins of exopods without hairs ; uniting lamella with a small rounded prominence on either side, bearing a few small spines on posterior face ; seg. 3 of endopod rather short. Endopod 3 of leg 4 generally about $1\frac{1}{2}$ times as long as wide ; outer apical spine much shorter than inner (63–81%), the latter a little longer than the segment ; outer seta reaching beyond the spine. Leg 5, basal segment broad ; seg. 2 nearly twice as long as wide, with slender apical seta and inner subapical spine, which is a little longer than the segment. Egg-sacs large, closely pressed to abdomen.

Male.—Length ·8–1 mm.

Leg 6 with very short inner spine; outer seta about 3 times as long as spine.

Distribution in Britain.

Recorded from a number of localities in England, Scotland, Ireland and Wales, but not from north of Skye. Apart from this, distribution gives no evidence of climatic influence.

Distribution Abroad.

Generally distributed throughout Europe.
Asia: Jana Territory (Sars); Tiflis (Richard).
Algeria, Biskra (R. G.).
Egypt: Ras el Ech, brackish water (R. G.).
Canada: Edmonton (R. G.).
New Zealand (Kiefer).
Novaya Zemlya (Scott).

Bionomics.

A eurytherm and euryhaline species, found generally in small ponds, often of temporary nature. Thienemann (1911) records its occurrence in water with a maximum salinity of 49·775°/$_{oo}$. It is not unusual to find it in brackish water, and it seems to be tolerant of a very wide range of conditions. For example, I have taken it in tree-holes in Windsor Forest, with *Moraria arboricola*. It is also recorded from spring waters (Klie, 1925) and caves (Graeter, 1910). Kreis (1921) has claimed it as a stenotherm cold-water form, which it certainly is not.

Roy (1932, p. 174) notes that *C. bisetosus* is generally found unaccompanied by other Entomostraca, and proved by experiment an inability to survive in competition with other Copepoda. He also found adults and eggs capable of surviving considerable periods of desiccation.

Cyclops bisetosus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Outer % of inner spine.	Inner spine % of end. 3.
Tyndrum, Scotland	·84	405	121	5·3	83	73	416	630	43	1·28	69	113
Jura	·83	372	130	4·8	80	69	396	585	48	1·47	74	100
Windsor Forest	·95	380	131	5·7	77	61	315	500	55	1·41	75	110
Fleet Pond, Hants	·91	384	143	5·6	78	67	375	528	49	1·37	63	110
Weybourne	1·05	350	145	6·2	78	67	320	457	57	1·94	81	110
,, ♂	·8	337	133	5·3	77	63	343	550	56	1·70	62	102
Sutton, Norfolk	1·16	320	128	6·7	83	53	310	420	39	1·72	73	100
Launceston	·78	405	126	4·85	82	64	395	590	41	1·78	65	104
Bodmin	·79	380	140	5·8	80	72	390	580	51	1·57	75	104
Abergele, Wales	·93	365	140	5·2	81	71	385	550	48	1·78	74	105
Algeria	1·12	321	116	5·2	81	53	270	427	52	1·72	68	124
C. crassicaudis.												
Edge Island	·99	363	100	4·25	78	57	282	434	35	1·25	74	124
Black Forest	·93	322	87	3·8	76	48	290	450	23	1·05	90	100
,, ♂	·75	332	87	3·5	67	53	370	550	47	1·12	62	117
Bear Island	1·0	350	100	4·0	66	51	292	410	39	1·14	77	106

Cyclops crassicaudis, Sars.

(Figs. 1686–1696.)

1863. *C. crassicaudis*, Sars, Forh. Vid. Selsk. Christ. p. 249.
1899. *C. brucei*, Scott, J. Linn. Soc. XXVII, p. 93, figs.
1901. *C. crassicaudis*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 57, figs.
1903. ,, Van Douwe, Zool. Anz. XXVI, p. 463, figs.
1913. ,, Sars, Crust. Norway, VI, p. 49, figs.
1923. ,, Kiefer, Zool. Anz. LVI, p. 283.
1927. *C. c. brachycercus*, Kiefer, *ibid.*, LXXII, p. 263, figs.
1928. *C. c. cretensis*, Kiefer, *ibid.*, LXXIX, p. 245, figs.
1929. *C. bissextilis*, Willey, Trans. R. S. Canada, XIX, p. 140.
1931. *C. c. taipehensis*, Harada, Annot. Zool. Jap. XIII, p. 158, fig.

Female.—Length ·93–1 mm.*

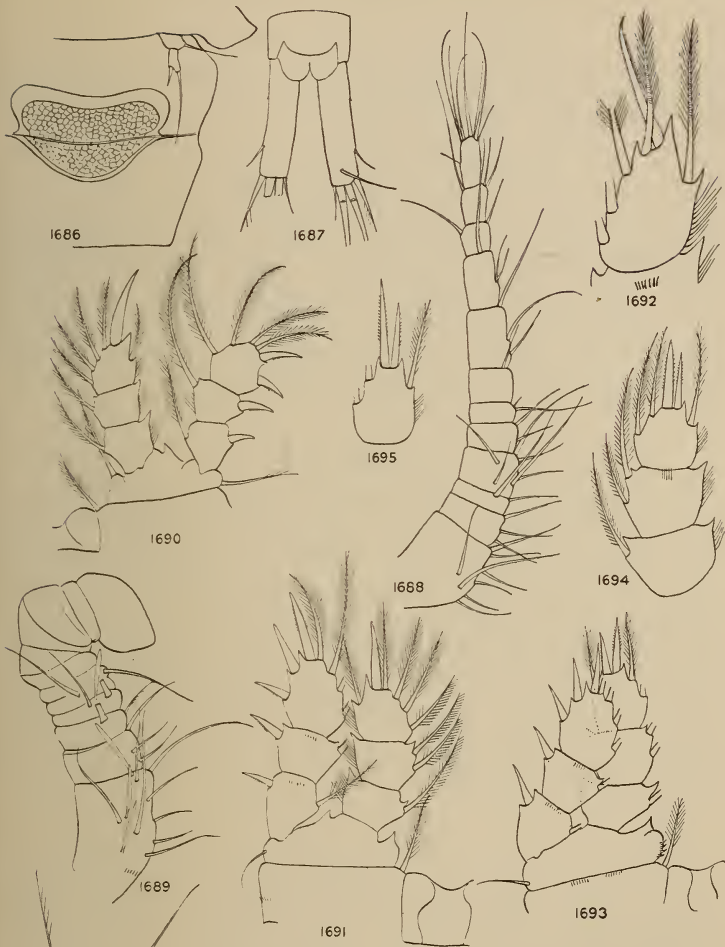
Body rather slender; th. som. 5 with angles sharply produced. Genital somite very large, as wide as long; receptaculum with anterior part concave in front, surrounded by a broad hyaline area. Operculum rather prominent. Furcal rami 4–5 times as long as wide; lateral seta inserted in distal third; inner apical seta shorter than outer. Antennule of 12 segments, reaching to end of cephalothorax; æsthete on seg. 9 long, hair-like. Legs short and stout; rami 3-segmented; basis of legs 2–4, with a group of small spinules on inner angle. Leg 4, endopod 3 nearly as wide as long; inner apical spine longer than outer, and as long as, or longer than, the segment. Leg 5 of 2 segments, seg. 2 rather slender, with inner spine about as long as the segment. Egg-sacs large, slightly divergent.

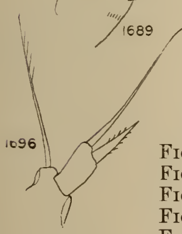
Colour milk-white.

Male.—Length ·75 mm.

Antennule of 17 segments; æsthetes of moderate length. Leg 3, endopod 3 with apical spine bent inwards, crossing distal seta. Spermatophores very large, kidney-shaped, placed longitudinally.

* Description made from specimens from the Black Forest kindly sent by Dr. Kiefer.





FIGS. 1686-1696.—*Cyclops crassicaudis.*

FIG. 1686.—Genital somite and receptaculum.
FIG. 1687.—Furcal rami.
FIG. 1688.—Antennule, female.
FIG. 1689.—Antennule, male, segs. 1-10.
FIG. 1690.—Leg 1.
FIG. 1691.—Leg 2, male.
FIG. 1692.—Leg 3, male, endopod.
FIG. 1693.—Leg 4.
FIG. 1694.—Leg 4, endopod.
FIG. 1695.—Leg 4, endopod 3. Edge Island.
FIG. 1696.—Leg 5.

(Figs. 1686-1694 and 1696 from specimens from the Black Forest.)

Distribution in Britain.

Recorded only by Southern and Gardiner (1926b, p. 43) from Lough Derg in Ireland.

Distribution Abroad.

Norway (Sars); Sweden (Lilljeborg); Spitzbergen (Olofsson); Franz Josef Land (Scott); North Russia (Rylov); Edge Island (A. G. L.); Germany (Van Douwe, etc.); Croatia (Krmpotic); France (Chevey); Algeria (Roy and Gauthier); Crete (Chappuis); North America (Willey, Kiefer); Bear Island (Bertram).

Bionomics.

Found only in very shallow water on moorland or under the shade of trees. According to Kiefer it lives commonly in small pools which dry up in summer, and are particularly cool, and is associated with *C. languidus*, *bisetosus* and *vernalis*. Olofsson found it to be monocyclic in Spitzbergen, but in south Germany Kiefer found no regular cycle, but that breeding continued as long as conditions were suitable. It is rarely found in summer. Brehm has claimed it as a glacial relict, but Kiefer disputes this.

Variation.

Kiefer has described two subspecies from the United States and Crete respectively. The former (*C. c. brachycercus*) differs only in the slightly shorter rami (3·2–3·4 : 1). It is said that the inner apical seta on endopod 3 in the male is spine-like, but this is also said to be the case in typical specimens (Kiefer, 1928h, p. 245). In a male from the Black Forest I find the condition as figured (Fig. 1692). *C. c. cretensis* has the endopod of leg 4 rather more elongated, but otherwise does not appear to differ from the type. *C. c. taipehensis*, Harada, has this endopod as in *C. c. cretensis*; with which it seems to be identical.

Cyclops Languidus-Group.

Recent work has shown that there exist a number of forms closely related to *C. languidus*, of which the systematic status is not clear. They all agree in the structure of the legs and in the form of the receptaculum, and constitute a well-defined group, While within this group three species can be separated by fairly well-marked characters (*C. languidus*, *nanus*, *abyssicola*), there are also a number of forms, which appear to be derived from *C. languidus*, to which it is difficult to assign a position. They are all regarded by Kiefer as subspecies, or forms, of *C. languidoides*, Lillj., but it is not certain that this arrangement correctly expresses relationship. It seems highly probable that some, at least, may be independently derived from *C. languidus* (or *C. nanus*) rather than all from one stem. Kiefer (1931) recognizes 11 distinct *languidoides* forms, but points out that, whenever any close study has been made of any such form, it has always been found to differ sufficiently from Lilljeborg's type to be given a special name, and that, if this process is to continue, it must end in complete confusion. It appears that *C. languidoides*, if it is a " species " at all, is an extremely variable and adaptable one, and it has even become difficult to separate it from *C. nanus*. *C. l. gracilicaudatus*, for example, can only be separated from the latter by the slightly different position of the lateral furcal seta. So far as this country is concerned there is not much difficulty in separating the *languidus*-forms known at present, and I follow Kiefer in treating three of them as subspecies of *C. languidoides*. I do so, however, simply as a convenience in labelling, and not with conviction that the system expresses relationship. If, as I think probable, some of these forms are independently evolved from *C. languidus*, the " species " *C. languidoides* is merely an " aggregate of convenience," and has no objective reality. Our system of nomenclature does not readily lend itself to satisfactory expression of the polyphyletic character of a species.

Key to the C. languidus-Group.

1. Antennule of 16 segments . . . . *C. languidus.*
   Antennule of 11 segments . . . . . . 2.
   Antennule of 10 segments . . . . *C. abyssicola.*
2. Lateral furcal seta in middle . . . . *C. nanus.*
   This seta in distal third . . . (*C. languidoides.*) 3.
3. Furcal rami 6, or more, times as long as wide . . 4.
   Less than 6 times as long . . . . 6.
4. Leg 4, endopod 3, twice as long as wide *C. l. gracilicaudatus.*
   This segment less than twice as long . . . . 5.
5. Inner spine of leg 4, endopod 3, longer than segment *C. l. hiberniæ.*
   This spine shorter than seg. . . . . *C. l. putealis.*
6. Leg 4, endopod 3, more than twice as long as wide *C. l. nagysalloënsis.*
   This segment less than twice as long . . . . 7.
7. Inner apical spine longer than endopod 3 . *C. l. eriophori.*
   This spine shorter than endopod 3 . . . . 8.
8. Rami 3 times, or less, longer than wide . . . . 9.
   Rami 4 times as long . . . . 11.
9. Inner apical seta longer than outer . . *C. l. zschokkei.*
   This seta shorter than outer. . . . . . 10.
10. Rami about 2½ times as long as wide . . *C. l. hypnicola.*
    Apical spines much shorter than endopod 3 . . .
    Rami 3 times as long ; spines nearly as long as endopod 3 *C. l. clandestinus.*
11. Endopod 3 1½ times as long as wide *C. languidoides* type, *C. l. forma gotica.*
    Endopod 3 nearly as wide as long . *C. l. forma italiana.*

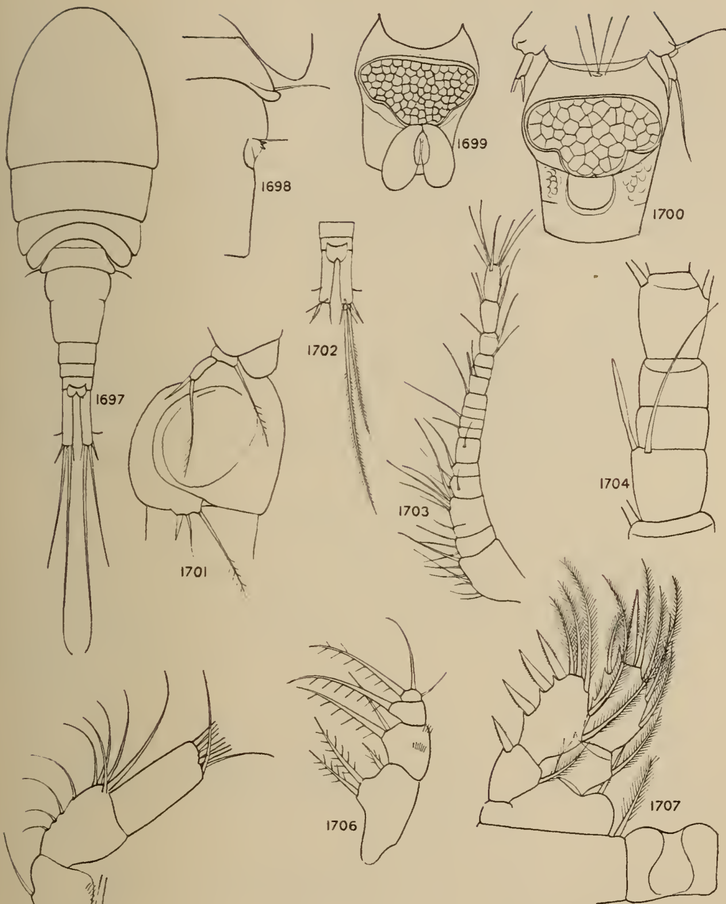
Cyclops languidus, Sars.

(Figs. 1697–1712.)

1863. *C. languidus,* Sars, Forh. Vid. Selsk. Christ. 1862, p. 249.
1892. ,, Schmeil, Bibl. Zool. XI, p. 84, figs.
1901. ,, Lilljeborg, Svenska Akad. Handl. XXXV, p. 49, figs.
1913. ,, Sars, Crust. Norway, VI, p. 50, figs.
1922. *C. l. forma atava,* Thallwitz, Zool. Anz. LIV, p. 266.
1926. *C. languidus,* Kiefer, Int. Rev. Hydrob. XIV, p. 342, figs.
1927. *C. l.* var. *disjuncta,* Thallwitz, Zool. Anz. LXXI, p. 59, figs.
1929. *C. languidus,* Kiefer, Tierreich, Lief. LIII, p. 61.

Female.—Length ·73–·94 mm.

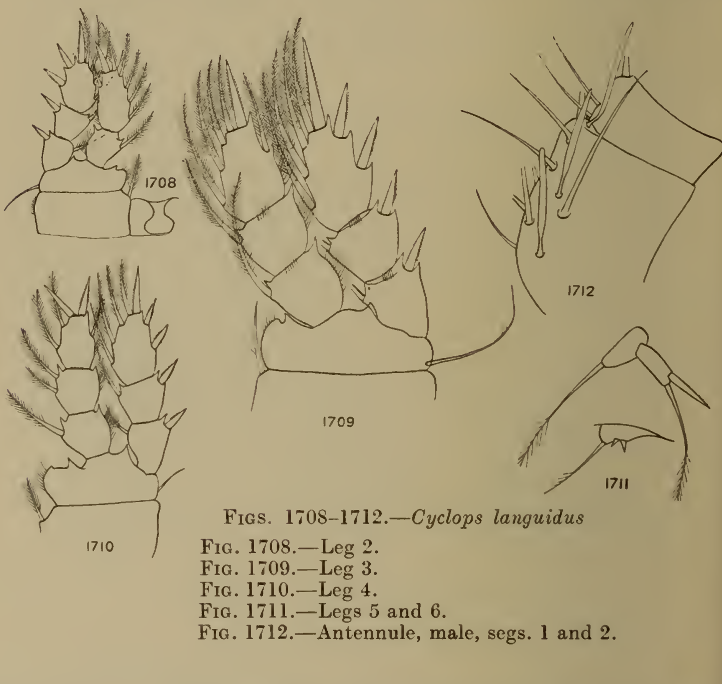
Body rather slender and flattened ; th. som. 5 with outer angle slightly upturned. Genital somite wide in front, with deep constriction a little before middle, and



FIGS. 1697–1707.—*Cyclops languidus.*

FIG. 1697.—Female, dorsal.
FIG. 1698.—Th. som. 5 and genital somite, dorsal.
FIG. 1699.—Receptaculum and spermatophores.
FIG. 1700.—Receptaculum.
FIG. 1701.—Genital somite, male, lateral.
FIG. 1702.—Furcal rami, dorsal.
FIG. 1703.—Antennule, female.
FIG. 1704.—Antennule, female, segs. 11–14.
FIG. 1705.—Antenna.
FIG. 1706.—Maxillipede.
FIG. 1707.—Leg 1.

sometimes with trace of separation dorsally; width to length about 26 : 30. Receptaculum consisting of a large oval anterior part extending across whole somite, and a narrower posterior part, which is not always evident. The form, as Schmeil showed, depends upon the degree to which it is filled. Furcal rami nearly parallel, 4–5 times as long as wide, and about 120–130°/$_{oo}$ of body length; lateral seta inserted in distal third



Figs. 1708–1712.—*Cyclops languidus*
Fig. 1708.—Leg 2.
Fig. 1709.—Leg 3.
Fig. 1710.—Leg 4.
Fig. 1711.—Legs 5 and 6.
Fig. 1712.—Antennule, male, segs. 1 and 2.

(66–73%); inner apical seta very short, shorter than outer, and less than one-third of ramus; setæ 2 and 3 very long. Antennule of 16 segments, reaching about to end of cephalothorax, sometimes markedly shorter; seg. 3 undivided, or partially divided; æsthete on seg. 11. Legs with exopod of leg 1 and endopods of legs 1 and 2, 2-segmented, seg. 2 representing segs. 2 and 3; spine formula 3.3.3.3; seta formula for exopod 3 of legs 1–3, 5.4.4. Basis of characteristic form, the inner

extension with a small outer spine and inner small lobe. Basis of leg 1 with long inner seta reaching beyond endopod 1. Leg 3, endopod 2 with 1 seta only. Leg 4, endopod 2 with 2 setæ of about equal length; endopod 3 slender, the length 1·5–1·7 times width; terminal spines nearly equal, the inner a little the longer, but much shorter than seg. 3. Leg 5, seg. 1 small, but very wide; seg. 2 slender, with inner spine as long as segment, and placed very near apex. Egg-sacs very large, divergent.

Male.—Length ·59 mm.

Antennule with æsthetes of seg. 1 long. Leg 6 with strong inner spine and very long outer seta; middle seta not much longer than inner spine.

Distribution in Britain.

Scattered records for this species from Sutherlandshire to Dorset, and from Wales and Ireland, show that it is distributed throughout these islands without any climatic restriction.

Distribution Abroad.

Europe: Generally distributed.

Asia: Asia Minor, Ceylon (Daday), China, Japan (Kiefer).

Bionomics.

This is a species generally found in small pools, or very wet moss, but may be met with occasionally in almost any weedy water. Mr. Lowndes has some interesting observations on its wide tolerance of pH (1928B and D). He found that it could be bred equally well in water of pH 5·9 or 8·4, and that females taken from pH 3·5 would breed freely in water of 5·9. In none of these conditions was any structural variation noted. In view of the diversity of form in this group, and the supposed influence of pH, this result is remarkable.

Cyclops languidus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
1. Norfolk	·94	340	128	5·0	73	32	300	474	25	1·76	106	63
2. New Forest . . .	·73	370	123	4·5	73	47	260	..	41	1·60	111	68
3. Dorsetshire, Swanage .	·73	370	120	4·0	66	54	260	437	38	1·50	114	76
4. ,, ,, ♂ .	·58	378	138	4·3	69	65	390	725	79	1·74	123	84
5. ,, ,, ♂ .	·59	372	118	3·9	72	61	385	760	68	1·74	119	74
6. Ringwood, Well. . .	·71	380	100	3·5	78	53	266	422	48	1·5	100	76
7. ,, ,, ♂ . .	·61	..	118	4·6	64	57	..	..	60	1·83	120	78

Variation.

Included in the "*languidus*-group" there are a number of forms of which the specific status is doubtful; but it is customary to refer to *C. languidus* only those with antennules of 16 segments, and, within the species so restricted, variation is not very great. Schmeil has noted finding males with the rami of all legs 3-segmented, and Thallwitz has given this form the name *C. l. forma atava.* Thallwitz has also described a var. *disjunctus* which, with its short rami and leg 4 endopod 3, has the characters of *C. languidoides* except for the antennule. The form which I have described as *C. l. hiberniæ* is referred by Kiefer to *C. languidoides*, and is dealt with below. In a well at Ringwood I have found specimens with antennules of 16 segments associated with others with 11 segments, and indistinguishable from the latter except by size and antennules. It seems that the boundary between this and the following species is scarcely more than an artificial convention.

Cyclops languidoides, Lilljeborg.

1901. *C. languidoides,* Lilljeborg, Svenska Akad. Handl. XXXV, p. 61, figs.
1926. ,, Kiefer, Int. Rev. Hydrob. XIV, p. 344, figs.
1929. ,, Kiefer, Tierreich, Heft LIII, p. 62, figs.
1931. ,, Kiefer, Zool. Jahrb. LXI, p. 697.

Female.—Length ·72–·75 mm.

General form as in *C. languidus.* Furcal rami about 5 times as long as wide; lateral seta inserted about distal third (76%); inner apical seta shorter than outer. Antennule of 11 segments. Leg 4, endopod 3 shorter than in *C. languidus* (1 : 1·21–1·39); terminal spines nearly equal, the inner a little the longer, and much shorter than the segment.

This definition is taken from Kiefer (1926). This typical form has not been seen in this country.

Distribution.

Sweden, North Russia, Switzerland.

Cyclops languidoides.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
C. l. hiberniæ :												
1. Malahide, ♀ . .	·94	320	144	6·6	75	53	246	465	41	1·22	136	150
2. ,, ♂ . .	·725	320	151	5·4	75	62	317	510	54	1·00	142	159
C. l. hypnicola :												
3. Sutton, Norfolk .	·52	345	87	2·4	76	59	320	540	39	1·22	116	78
4. Buxton, ,, .	·47	362	96	2·5	73	61	320	535	53	1·28	122	77
5. Cothill, Berks. .	·46	347	83	2·4	67	54	290	445	45	1·20	108	68
6. Ringwood (Well.) .	·52	382	98	3·1	70	50	317	560	39	1·45	118	81
7. ,, . .	·48	375	102	3·15	73	60	320	590	56	1·50	130	87
C. l. eriophori :												
8. Ingham, Norfolk .	·67	375	91	2·9	67	45	270	535	25	1·04	128	114

C. nanus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
9. Norfolk . .	·7	340	128	4·85	68	54	277	457	43	2·0	106	75
10. ,, . .	·72	332	110	5·0	54	40	270	..	28	2·3	130	124
11. ,, . .	·72	332	110	4·8	56	41	276	465	34	2·6	126	112

The following subspecies or varieties have been described, apart from those mentioned below :

1925. *C. languidulus*, Willey, Trans. Roy. Soc. Canada (3), XIX, p. 141.
1926. *C. l. clandestinus*, Kiefer, Schr. Ver. Donaueschingen, XVI, p. 276, figs.
1926. *C. l. zschokkei*, Graeter, Arch. Hydrob. VI, p. 42, figs.
1927. *C. l. nagysalloënsis*, Kiefer, Zool. Anz. LXXI, p. 6, figs.
1928. *C. l. putealis*, Chappuis, Bull. Soc. Cluj. IV, p. 21.
1931. *C. l. forma italiana* and *f. gotica*, Kiefer, Zool. Jahrb. LXI, p. 697, figs.

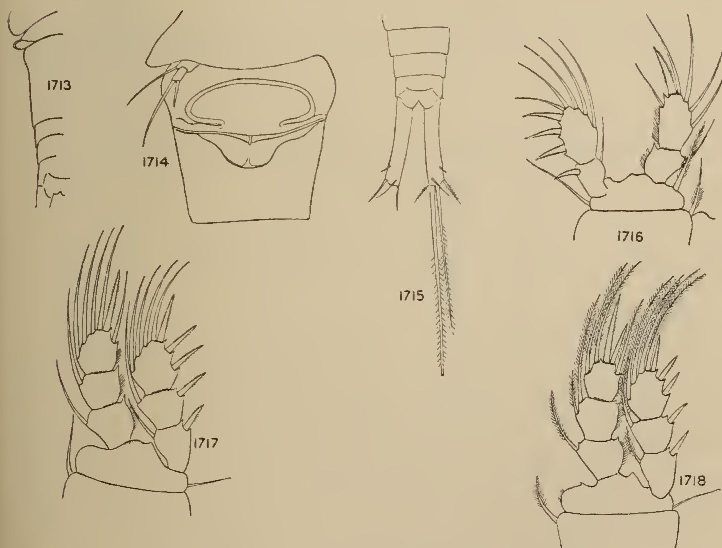
Cyclops languidoides hiberniæ, Gurney.

(Figs. 1713–1718.)

1927. Gurney, Ann. Mag. Nat. Hist. (9) XIX, p. 498, figs.

Female.—Length ·84–·94 mm.

Th. som. 5 slightly upturned at outer angles ; genital



FIGS. 1713–1718.—*Cyclops languidoides hiberniæ.*

FIG. 1713.—Th. som. 5 and abdomen, dorsal.
FIG. 1714.—Receptaculum.
FIG. 1715.—Furcal rami.
FIG. 1716.—Leg 1.
FIG. 1717.—Leg 3.
FIG. 1718.—Leg 4.

somite and receptaculum as in *C. languidus*. Furcal rami 6–7 times as long as wide; lateral seta inserted in distal third; inner apical seta shorter than outer, and less than one-third of length of ramus. Leg 3, endopod 2 with one seta. Leg 4, endopod 2, proximal seta less than half length of distal; endopod 3 nearly as wide as long; outer apical spine shorter than inner, the latter much longer than endopod 3. Leg 5 of 2 distinct segments.

Male.—Length ·72 mm.

As in female, but inner apical seta of rami longer.

Occurrence.

In a small pool near the estuary at Malahide (co. Dublin), September, 1920.

Pembrokeshire: In mouth of small stream entering the sea near Newport (D. J. S.).

Anglesey: In cistern by Red Wharf Bay (D. J. S.).

Cyclops languidoides hypnicola, Gurney.

(Figs. 1719–1725.)

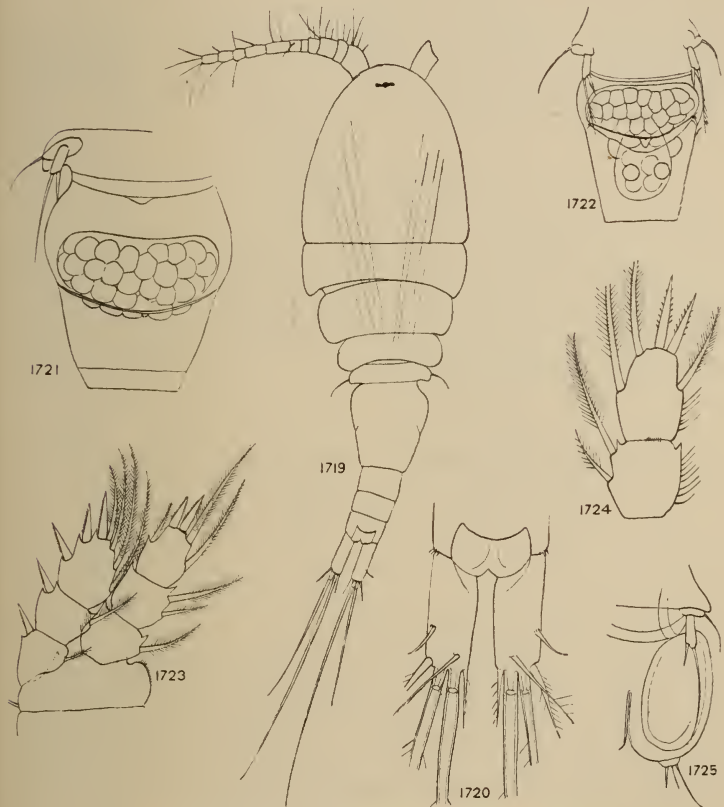
1927. Gurney, Ann. Mag. Nat. Hist. (9) XIX, p. 501, figs.

Female.—Length ·46–·53 mm.

Th. som. 5 without upturned angles; furcal rami about $2\frac{1}{2}$ times as long as wide; lateral seta inserted at beginning of distal third (63–76%); inner apical seta shorter than outer, and less than half length of ramus. Leg. 4, endopod 3 little longer than wide (1 : 1·2); apical spines nearly equal, and much shorter than endopod 3. Leg 5, seg. 1 more or less fused with th. som. 5.

The only marked difference between this form and *C. l. clandestinus* is in size, the latter being much

larger. They differ also in the greater length of the rami in *C. l. clandestinus* and the position of the lateral seta. I refer to this form also specimens from wells at



FIGS. 1719–1725.—*Cyclops languidoides hypnicola.*

FIG. 1719.—Female, dorsal. Ringwood.
FIG. 1720.—Furcal rami. Norfolk.
FIG. 1721.—Receptaculum. Ringwood.
FIG. 1722.—Receptaculum. Norfolk.
FIG. 1723.—Leg 4. Norfolk.
FIG. 1724.—Leg 4, endopod 3. Ringwood.
FIG. 1725.—Legs 5 and 6, male.

Walsingham (Norfolk) and Ringwood (Hants). These have longer rami and more slender leg 4, and are with difficulty separable from C. *l. clandestinus*.

Distribution.

Norfolk : A number of localities in the Broads district and elsewhere. Well at Walsingham (R. G.).
Hampshire : Well at Ringwood (R. G.).
Berkshire : Cothill and Frilford (R. G.).
Holland : Friesland (R. G.).
Scotland : Jura (R. G.).

Bionomics.

Very common in submerged moss in shallow water round the Broads, and in similar situations at Cothill, Frilford and in Friesland. The specimens from wells were taken in company with *Niphargus* and (at Ringwood) with *Asellus cavaticus.*

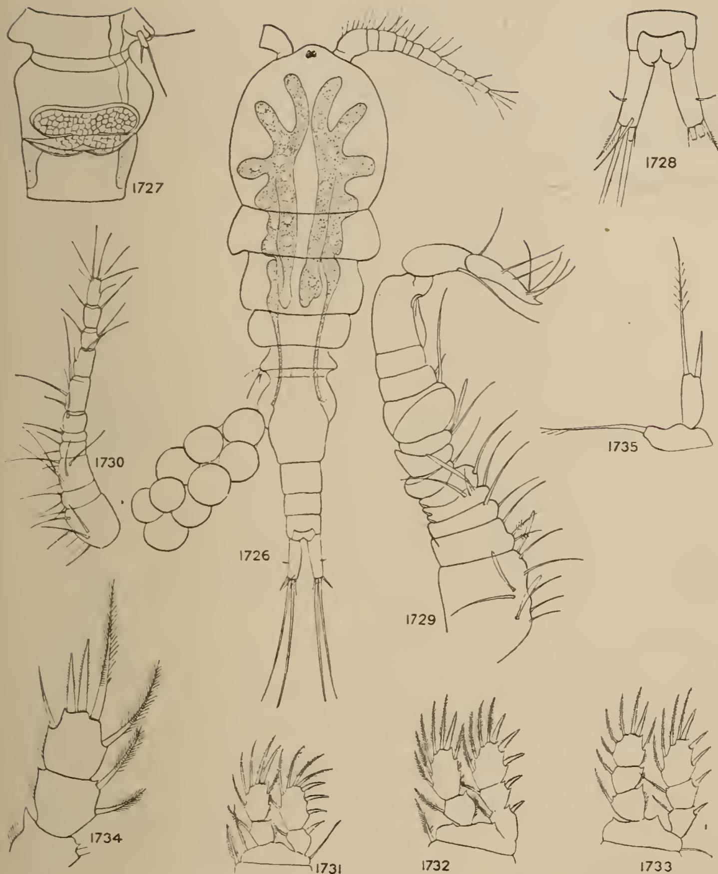
Cyclops languidoides eriophori, Gurney.

(Figs. 1726–1735.)

1927. Gurney, Ann. Mag. Nat. Hist. (9), XIX, p. 503, figs.

Female.—Length ·59–·7 mm.

Th. som. 5 not upturned at angles ; genital somite very wide, width equal to length, and much exceeding width of succeeding somites. Receptaculum differing from typical form, the anterior part narrow, concave in front. Furcal rami divergent, slightly curved, rather variable ; length 3–3·5 times the width ; lateral seta inserted a little beyond middle (67%) ; inner apical seta scarcely more than half outer. Leg 4, endopod 2, proximal seta about two-thirds as long as distal, the latter scarcely longer than seg. 3 ; endopod 3 nearly, or quite, as wide as long ; apical spines nearly equal, the inner spine longer than endopod 3 ; apical seta very much longer than the spines, but outer seta either not reaching end of spines, or but little longer. Leg 5, seg. 1 distinct.



FIGS. 1726–1735.—*Cyclops languidoides eriophori.*

FIG. 1726.—Female, dorsal.
FIG. 1727.—Genital somite and receptaculum.
FIG. 1728.—Furcal rami.
FIG. 1729.—Antennule, male.
FIG. 1730.—Antennule, female.
FIG. 1731.—Leg 1.
FIG. 1732.—Leg 2.
FIG. 1733.—Leg 3.
FIG. 1734.—Leg 4, endopod.
FIG. 1735.—Leg 5.

Distribution.

Found only in a marsh at Ingham, Norfolk. The marsh is flooded only in winter and spring, and is covered with a pure growth of *Eriophorum*. The *Cyclops* lives among the decaying leaves of the plant, in water only an inch or two deep, and no other entomostraca were found with it.

Cyclops nanus, Sars.

(Figs. 1736–1746.)

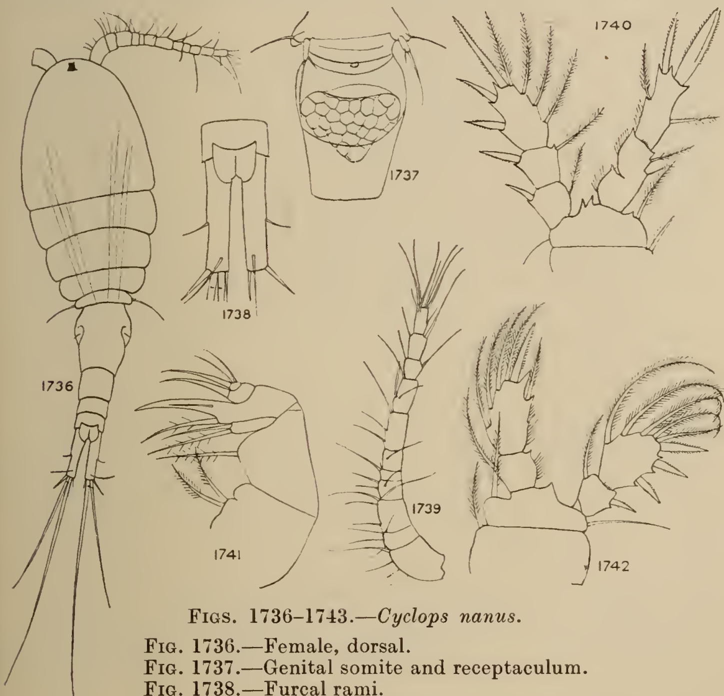
1863. *C. nanus*, Sars, Forh. Vid. Selsk. Christ. 1862, p. 251.
1897. *C. languidus* var. *nanus*, Schmeil, Bibl. Zool. XXI, p. 151.
1901. *C. diaphanus*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 63, figs.
1903. *C. nanus*, Scourfield, J. Quekett Micr. Cl. (2), IX, p. 534, figs.
1903. *C. d.* var. *diaphanoides*, Graeter, Rev. Suisse, XI, p. 535, figs.
1905. *C. incertus*, Wolf, Zool. Jahrb. XXII, p. 161, figs.
1913. *C. diaphanus*, Sars, Crust. Norway, VI, p. 52, figs.
1913. *C. languidoides*, Klie, Int. Rev. Hydrob. Biol. Suppl. VI, p. 6.
1924. *C. l.* var. *intermedia*, Kiefer, Zool. Anz. LVIII, p. 278.
1925. *C. nanus*, Kiefer, Mikrokosmos, Jg. 18, p. 243, figs.
1926. ,, Kiefer, Int. Rev. Hydrob. XIV, p. 348, figs.
1927. ,, Gurney, Ann. Mag. Nat. Hist. (9), XIX, p. 504, figs.

Female.—Length ·7–7·2 mm.

Th. som. 5 with angles not upturned; genital somite very broad in front, width about equal to length. Receptaculum as in *C. languidus*. Furcal rami about 110°/∘∘ of body, and 5 times as long as wide; lateral seta inserted almost in middle; inner apical seta shorter than outer. Antennule of 11 segments, shorter than cephalothorax; æsthete on seg. 8 very long. Legs with rami segmented as in *C. languidus*, but more slender, and with longer spines; leg 3, endopod 2 with one inner seta. Leg 4, endopod 2, proximal seta less than half length of distal; endopod 3 more than twice as long as wide; inner apical spine longer than outer, and longer than endopod 3. Leg 5 generally with seg. 1 distinct, but frequently more or less fused with the somite; seg. 2 slender, with long inner spine.

Schmeil regarded this species as merely a variety of *C. languidus*. Its independent status was established

by Lilljeborg, but he introduced confusion between it and the species partially described by Schmeil as *C. diaphanus*, Fischer, since he described *C. nanus* under the name of *C. diaphanus*, and gave as a synonym *C. minutus*, Claus, which is, without doubt, the same as *C. diaphanus*, Schmeil, and a perfectly distinct species.



FIGS. 1736–1743.—*Cyclops nanus.*

FIG. 1736.—Female, dorsal.
FIG. 1737.—Genital somite and receptaculum.
FIG. 1738.—Furcal rami.
FIG. 1739.—Antennule, female.
FIG. 1740.—Leg 4, abnormal.
FIG. 1741.—Maxilla.
FIG. 1742.—Leg 1.
FIG. 1743.—Leg 2.

Sars repeated Lilljeborg's error. Whether Fischer's species was identical with *C. nanus*, or *C. minutus*, Claus, it is impossible to say, since his description is incomplete, but, if speculation is allowable, it is most reasonable to assume that it was *C. minutus*, since it is improbable that he would have failed to mention the peculiar segmentation of the legs if he had had *C. nanus*. However that may be, it is clear that Fischer's name

must be dropped, having been applied to two quite different species. Lilljeborg and Sars seem to have actually confused the two species, since the former figures a receptaculum which could not possibly be that of *C. nanus*, and Sars's figure of leg 5 resembles that of *C. minutus*, and by no means that of *C. nanus*.

Figs. 1744–1746.—*Cyclops nanus.*

Fig. 1744.—Leg 3.
Fig. 1745.—Leg 4.
Fig. 1746.—Leg 5.

Variation.

There is much individual variation in the degree to which seg. 1 of leg 5 is fused with the somite. Kiefer distinguishes three forms, forma *typica*, f. *diaphanoides*, and subsp. *incertus*, Wolf, according to whether this segment is free, partly fused, or wholly fused with the somite. I have never found this segment wholly lost, as figured by Sars and by Wolf, but partial fusion is certainly an individual variation, and not characteristic of races.

Distribution in Britain.

Scotland: Near Loch Lomond (Scott); Loch Lomond (R. G.); Skye (A. G. L.); Mallaig, Corrour, Jura. Sutherlandshire (R. G.).

South Wales: St. David's, Newport (D. J. S.).

North Wales: Berwyn mountains, Conway, etc. (R. G.).

Ireland: Achill Island (D. J. S.); Bog of Allen, Hollybrook, etc. (R. G.).

England: Norfolk: many localities (R. G.).
Hampshire: New Forest (R. G.).
Dorsetshire: Swanage (R. G.).
Warwickshire: Birmingham (A. G. L.).
Cumberland: Lake District (R. G., D. J. S.).
Cheshire: Oakmere (D. J. S.).
Yorkshire: Wensleydale (D. J. S.).

Distribution Abroad.

The distribution is not certainly known, since there has been much confusion with forms of *C. languidoides*. Kiefer gives its distribution as covering most of Europe, but it has not been seen outside Europe.

Bionomics.

A summer form, found in mossy pools, often in company with *C. languidoides hypnicola*.

Subgenus **MICROCYCLOPS**, Claus.

1893. *Microcyclops*, Claus, Anz. Akad. wiss. Wien, No. 9, p. 82.
1927. *Cryptocyclops*, Sars, Ann. S. Afr. Mus. XXV, p. 129.
1929. *Microcyclops*, *Metacyclops*, *Bryocyclops* and *Diacyclops* (part), Z. wiss. Zool. CXXXIII, pp. 41, 44, and Tierreich, Lief. LIII, pp. 64, 66, 72.

Antennule with 10–12 segments; swimming-legs with rami 2-segmented; leg 5, seg. 1 fused with th. som. 5; seg. 2 usually small, cylindrical, with apical seta and with, or without, inner or subapical spine.

Type.—*C. varicans*, Sars.

Claus included in his subgenus *C. gracilis*, *C. minutus* and *C. bicolor*, and Sars, nearly forty years later, set up his new genus *Cryptocyclops* for exactly the same group of species. Neither expressly designated a type. Kiefer uses the subgenus in a restricted sense, to include only *C. varicans*, *C. bicolor* and their allies, setting up a new subgenus *Metacyclops* for *C. gracilis*, *C. minutus*, etc. He regards *C. varicans* and *C. bicolor* as typical of two diverging lines in *Microcyclops*, and recognizes that, within *Metacyclops*, there are two subgroups, of which *C. minutus* and *C. gracilis* are the types. Kiefer's two subgenera correspond exactly to Schmeil's "*varicans-bicolor*" and "*gracilis-diaphanus*" groups, and it must be admitted that they appear to be natural groups. On the other hand *Metacyclops* seems, as suggested above (p. 146), to comprise three, and not two, subgroups, and there is no means of knowing whether these subgroups are more nearly related to each other than either is to the *varicans* group. The only character in which they differ as a whole from *Microcyclops*, Kiefer, is in the apical position of the spine on leg 5—a character upon which I cannot lay the stress that Kiefer does. If so much importance is to be attached to such small differences in this leg, it is not possible to include *C. dengizicus* in *Metacyclops*, or indeed in any other subgenus, since its leg 5 is quite unlike that of any other species except *C. panamensis*. With *C. panamensis* (and *C. jeanneli*) it shares the peculiarity of having an apical seta and spine, instead of two spines, on the endopod of leg 4, and it is further remarkable for having a denticulate operculum. The systematic position of *C. gracilis* has been a matter of difficulty. While Schmeil grouped it with *C. minutus*, Sars, mainly relying upon the form of the receptaculum, placed it in *Mesocyclops*, a position accepted by Kiefer and others. In the general form of the body it resembles *Mesocyclops*, but similar modification of form in limnetic species is seen in *C. prasinus* and *C. tenellus*. The form of receptaculum is not decisive, since a similar shape is

found in *C. mendocinus*, which is certainly related to *C. minutus*. Sars later (1927) returned to Schmeil's view, and has been followed by Kiefer.

Although we are able to point with reasonable probability to certain divergent lines within the subgenus *Microcyclops*, Claus, it is impossible to define them with any approach to the clearness necessary for practical application, and it seems to me very much better to retain the name in its original sense for all the species with reduced segmentation of the legs, being content to indicate subsidiary groupings without attempting to reduce them to definition.

Key to the British Species of the Subgenus Microcyclops.

1. Leg 5 obsolete, represented by 3 setæ on margin of th. som. 5 . . . *C. demetiensis*.
   Leg 5, seg. 2 distinct . . . . 2.
2. Operculum large, triangular; leg 5, seta of seg. 1 lost . . . *C. unisetiger*.
   Operculum not prominent; leg 5, seta of seg. 1 springing from th. som. 5 . . . . . . 3.
3. Leg 1, basis without inner seta; leg 4, endopod 2 with one apical spine only . . . . . *C. minutus*.
   Leg 1, basis with seta; leg 4, endopod 3 with 2 spines . 4.
4. Leg 5, seg. 2 with inner spine apical; receptaculum hammer-shaped . . . . *C. gracilis*.
   Leg 5, seg. 2 inner spine in middle, or absent; receptaculum not hammer-shaped . . . . 5.
5. Leg 4, outer apical spine more than half length of inner spine . . . *C. varicans*.
   This spine less than one-third of inner spine . . *C. bicolor*.

Cyclops varicans-Group.

It is extraordinarily difficult to form an opinion as to the validity of the species *C. varicans*, Sars, and its nearest allies. Lilljeborg's species *C. rubellus* has been generally accepted, though Sars, who cannot be accused of minimizing differences, regarded the two as identical. Kiefer accepts *C. rubellus*, and also separates as subspecies *C. v. subæqualis*, on the basis of the longer spines

on leg 4 endopod. As he points out, Sars's and Lilljeborg's figures of *C. varicans* differ in respect to these spines, and Lilljeborg's form, with long spines, reappears in several African localities. We are concerned here only with these four forms—*C. varicans*, Sars; *C. varicans*, Lilljeborg; *C. subæqualis*, Kiefer; *C. rubellus*, Lillj.

The first two forms both occur in this country (see Table, nos. 1, 3), and, apart from the single point that these spines are longer in the one case than in the other, they are identical. I have had specimens named by Lilljeborg (Norman Collection), and others from Holland, and these agree with the Norfolk specimens. It should particularly be noted that I have found associated together a male and a female which differ in the length of these spines (Table, nos. 3, 4). It is remarkable that there should be a sort of dimorphism in respect of this character, but that is what it seems to be, and I see no reason for separating these forms. As regards *C. rubellus*, the position is not so simple. I have myself recognized in Norfolk two species which, in life, are easily separated by colour and form of receptaculum; but neither of these characters is available for preserved material, and I also now find that the colour criterion is fallible, since colourless specimens may have the receptaculum of *C. rubellus*. Lowndes (1928, p. 339) gives the characters in which *C. rubellus* differs from *C. varicans*: (1) Smaller size; (2) furcal rami shorter; (3) leg 5 without inner spinule; (4) furcal seta 4 longer than ramus; (5) leg 4, endopod 3 stouter, and spines subequal and short. If the figures given in the table are compared, it will be seen that these differences are exceedingly small. The difference in length of ramus is scarcely more than 5%, and there is complete overlap in the ratio of length to width. The inner seta is definitely shorter in *C. varicans*, but not always. Leg 4 endopod 3 is not always stouter than in *C. varicans* but the spines seem to be shorter. I have included in the table specimens from Ceylon and Rangoon. In

some of these specimens in which the receptaculum is visible it is of the *varicans* form, but in others quite clearly of the form of *rubellus*. There are also among them specimens with long and others with short spines. I am unable now to compare the receptaculum of European specimens, as I have failed to get fresh material, but it seems that too much stress has been laid on the difference between the two forms in this respect. I reproduce here six figures of the receptaculum of *C. varicans* given by different authors, and it will be seen that the agreement is not very close. In these circumstances I feel that no purpose is served by maintaining *C. rubellus* as an independent species. At the same time, simply to dismiss it as a synonym of *C. varicans* may, at this stage, be going too far, and I include it as a subspecies of the latter both in deference to general opinion, and also to draw attention to it as a form requiring further study.

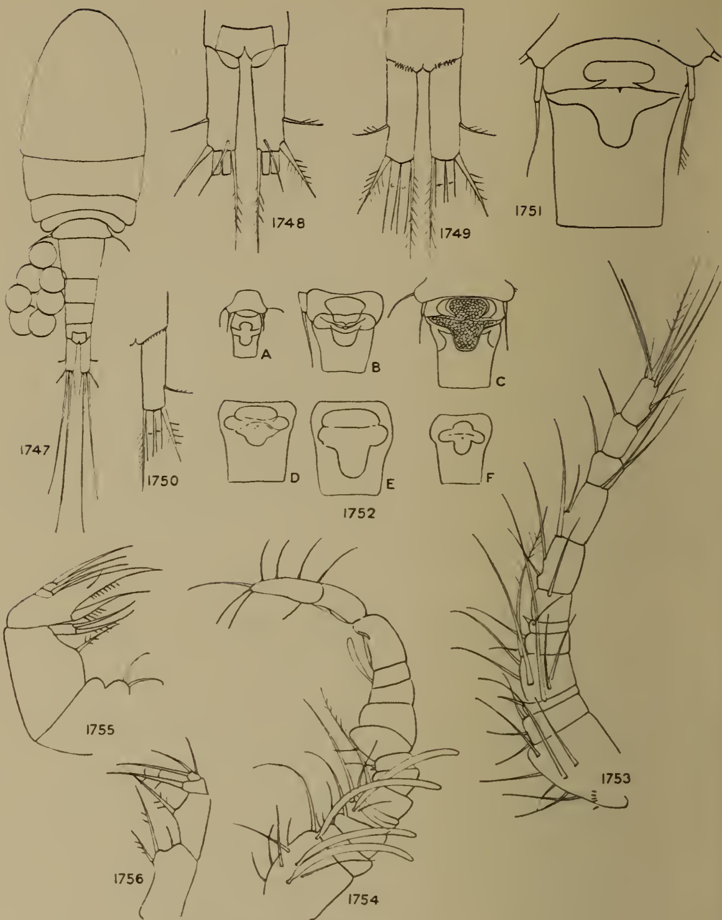
Cyclops varicans, Sars.

(Figs. 1747–1764.)

1863. *C. varicans,* Sars, Forh. Vid. Selsk. Christ. 1862, p. 252.
1875. *C. orientalis,* Uljanin, Nachr. Ges. Moskau, XI, p. 33, figs.
1892. *C. varicans,* Schmeil, Bibl. Zool. XI, p. 116, figs.
1893. *Microcyclops varicans,* Claus, Arb. Z. Inst. Wien, X, p. 347.
1893. *C. africanus,* Bourne, Proc. Zool. Soc. Lond. p. 165, figs.
1901. *C. varicans,* Lilljeborg, Svenska Akad. Handl. XXXV, p. 72, figs.
1913. ,, Sars, Crust. Norway, VI, p. 54, figs.
1919. *C. ceibaensis,* Marsh, Proc. U.S. Nat. Mus. LV, p. 546, figs.
1927. *C. subæqualis,* Kiefer, Faune Colon. Franç. I, p. 558, figs.
1929. *C. varicans,* Kiefer, Z. Wiss. Zool. CXXXIII, p. 29, figs.
1929. *C.* (*Microcyclops*) *varicans,* Kiefer, Tierreich, Lief LIII, p. 66, figs.
1932. *C. v. subæqualis,* Kiefer, Arch. Naturg. N.F. I., p. 249.

Female.—Length ·6–·9 mm.

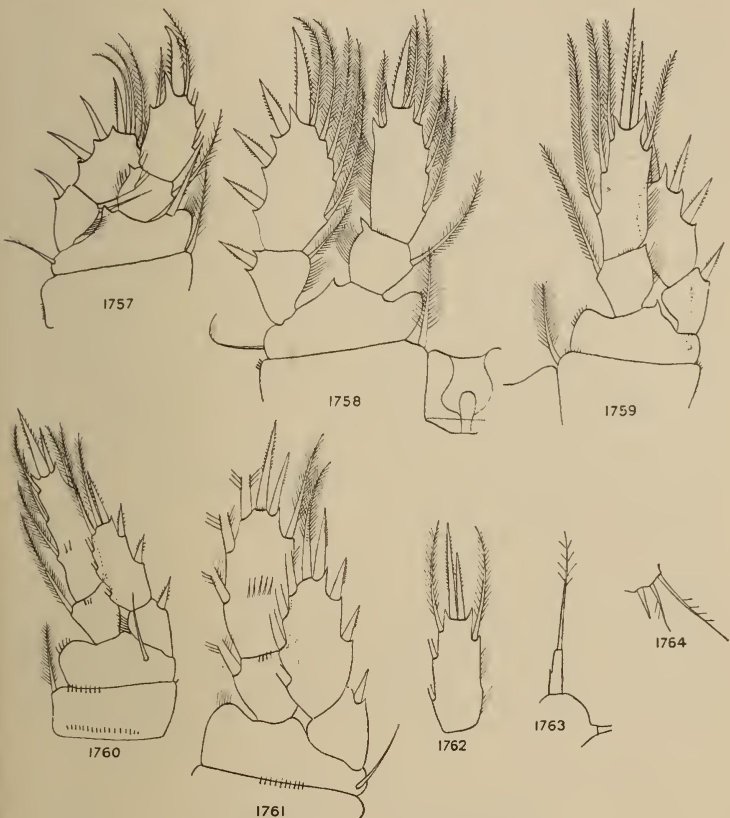
Cephalothorax oval, greatest width in middle; th. som. 5 bearing a seta on either side. Genital somite not much widened in front; receptaculum variable (Fig. 1752), typically with anterior and posterior parts equal, and together forming an ovoid sac (Sars, Schmeil); more commonly with anterior part more or less transversely flattened. Abd. som. 5 with a series of rather



FIGS. 1747–1756.—*Cyclops varicans.*

FIG. 1747.—Female, dorsal.
FIG. 1748.—Furcal rami, dorsal.
FIG. 1749.—Furcal rami, ventral.
FIG. 1750.—Furcal rami, ventral. Scotland.
FIG. 1751.—Receptaculum.
FIG. 1752.—Receptaculum after various authors. A, Schmeil; B, Graeter; C, Claus; D–F, Kiefer.
FIG. 1753.—Antennule.
FIG. 1754.—Antennule, male.
FIG. 1755.—Maxilla.
FIG. 1756.—Maxillipede.

large spines ventrally at base of ramus, often reduced to about 6 spines, not extending to sides. Furcal rami



FIGS. 1757–1764.—*Cyclops varicans.*

FIG. 1757.—Leg 1.
FIG. 1758.—Leg 3.
FIG. 1759.—Leg 4. Holland.
FIG. 1760.—Leg 4. Rangoon.
FIG. 1761.—Leg 4. Norfolk, male.
FIG. 1762.—Leg 4, endopod 2. Uppsala, Sweden.
FIG. 1763.—Leg 5.
FIG. 1764.—Leg 6, male.

parallel, generally 3–4 times as long as wide, rarely about $2\frac{1}{2}$ times; lateral seta inserted at beginning of distal third (64–70%); inner apical seta considerably

longer than outer seta, and shorter than ramus, occasionally equal to it, or very rarely longer. Antennule of 12 segments, not reaching end of cephalothorax; occasionally seg. 3 is undivided; seg. 9 with club-shaped æsthete. Legs with rami 2-segmented, with spine formula 3.4.4.3. Leg 1 basis with very long inner spine, reaching beyond middle of endopod 2. Legs 2–4, basis with small spinules on inner angle. Leg 4 smaller than leg 3 and turned outwards so as to be visible from above in life; exopod 1 without inner seta; endopod 2 generally $2\frac{1}{2}$ times as long as wide, but variable; outer apical spine much shorter than inner, and the latter either nearly as long as seg. 2 or little more than half as long. Leg 5, seg. 1 fused with som. 5, its seta borne on outer angle of latter; seg. 2 very small, cylindrical, with one apical seta and a very small inner spinule. This spinule is difficult to see, and it is uncertain if it is invariably present.

Colour: Greyish-white.

Egg-sacs large, slightly divergent.

Male.—Length about ·5 mm.

Furcal rami shorter than in female, and inner apical seta much longer. Antennule with exceedingly large æsthetes on segs. 1 and 4; seg. 13 bears a large æsthete, but I have not been able to see one on seg. 9.

Distribution in Britain.

One of the rarest species.

Scotland: Shetlands; Lochs Roscobie and Balgavie, Forfarshire (Scott).

Ireland: Westport and Castlebar (D. J. S.), Lough Derg (R. G.).

England: Lake District (D. J. S.).

Norfolk: 16 localities in Broads district (R. G.).

Cambridge: Wicken Fen (A. G. L.).

Essex: Epping (D. J. S.).

Wales: Anglesey (D. J. S.).

Cyclops varicans.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of seg. 2.
1. Isle of Wight . .	·6	334	83	2·63	68	65	335	455	82	2·27	133	63
2. Devonshire . .	·71	365	84	3·45	70	56	350	520	105	..	..	..
3. Sutton, Norfolk .	·75	360	93	3·82	69	53	362	477	92	2·92	138	83
4. ,, ,, ♂ .	·48	..	73	2·34	57	58	..	..	..	2·0	136	64
5. Uppsala, Sweden .	·89	337	91	3·85	67	56	326	425	..	2·9	146	86
6. ,, ,, .	·83	337	96	3·6	64	60	..	..	84	2·15	142	90
7. Naardermeer, Holland	·75	345	93	3·15	68	56	356	470	93	2·5	143	100
8. ,, ,, ♂	·49	327	76	2·75	68	72	310	460	167	2·3	139	85
9. Ceylon . . .	·61	360	98	4·0	69	..	..	..	..	3·0	162	58
10. ,, . . .	·56	355	100	4·0	57	56	305	480	89	2·5	210	77
11. ,, . . .	·66	350	98	4·0	67	60	320	440	78	2·8	168	60
12. ,, . . .	·66	362	106	4·2	68	60	..	..	83	3·12	192	64
13. ,, . . .	·58	380	92	3·4	70	69	310	480	87	2·9	175	60
14. ♂ ,, . . .	·475	315	86	2·78	64	63	..	..	102	2·5	184	78
15. ,, . . .	·52	365	96	3·2	68	58	325	390	122	2·0	174	87
16. ,, . . .	·62	400	97	2·9	63	80	400	600	..	2·07	160	93
17. Rangoon . . .	·66	376	103	3·75	62	60	320	450	91	2·57	152	64
18.	·70	340	103	4·35	71	57	285	430	87	2·85	164	57
19. Victoria, S. Australia *	·815	306	87	4·0	66	56	303	437	99	2·86	138	67
20. ,, ,, *	·835	312	89	3·75	64	50	310	495	97	2·9	140	75
21. *C. v.* var. *furcata* Daday*	1·1	410	107	4·1	61	55	227	365	73	..	120	67

* Specimens from the collection of G. O. Sars.

Distribution Abroad.

Europe: Generally distributed.

Asia: Manchuria (Rylov); Palestine (Krampner, Richard); India, Lahore (R. G.); Ceylon (R. G.); Rangoon (R. G.).

Africa: Egypt (Chappuis, Graeter, R. G.); East Africa (Daday); Tanganyika* (Sars); Central Africa (Van Douwe); Cameroons, Togoland (Kiefer); N. Nigeria (R. G.).

North America: U.S.A. (Marsh, etc.); Canada (Willey).

South America: Patagonia (Daday); Paraguay (Daday); Brazil (Van Douwe).

New Zealand (Sars).

Australia: New South Wales (Henry).

Cyclops varicans rubellus, Lilljeborg.

(Figs. 1765–1770.)

1901. *C. rubellus*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 75.
1905. *C. varicans* var. *rubens*, Wolf, Zool. Jahrb. Syst. XXII, p. 173.
1922. *C. davidi*, Chappuis, Rev. Suisse Zool. XXIX, p. 172, figs.
1927. ,, Kiefer, Faune Colon. Franç. I, p. 560, figs.
1928. *C. rubellus*, Lowndes, N. H. Wicken Fen, IV, p. 338, figs.
1929. ,, Kiefer, Z. wiss. Zool. CXXXIII, p. 35, figs.

Female.—Length ·6–·9 mm. (Lilljeborg).

Differing, typically, from *C. varicans* as follows:

(1) Abd. som. 5 with series of very small spines at base of rami.

(2) Furcal rami shorter, generally 2½–3 times as long as wide.

(3) Inner apical seta as long as, or longer than, ramus.

(4) Leg 4, endopod 3 not much more than twice as long as wide. Apical spines not very unequal, and inner spine about half length of segment.

(5) Leg 5 without inner spinule.

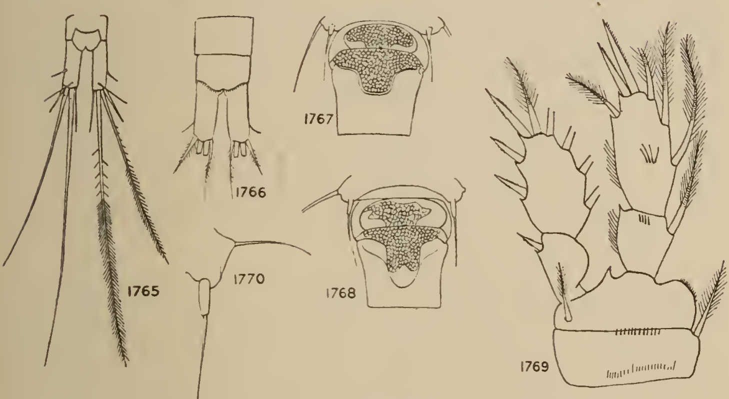
(6) Receptaculum ?

The antennule may be of 11 or 12 segments, usually the latter.

* Specimens of the "*subæqualis*" form, in the British Museum, labelled by Prof. Sars.

Distribution in Britain.

Lake District (Sprague, D. J. S.).
Norfolk : 13 localities in Broads district (R. G.).
Cambridge : Wicken Fen (A. G. L.).
Ireland : Clare Island (D. J. S.).
Warwickshire : Birmingham (A. G. L.).
Essex : Epping (D. J. S.).
Isle of Man (D. J. S.).



Figs. 1765–1770.—*Cyclops varicans rubellus.*

Fig. 1765.—Furcal rami, dorsal.
Fig. 1766.—Furcal rami, ventral.
Fig. 1767, 1768.—Receptaculum.
Fig. 1769.—Leg 4.
Fig. 1770.—Leg 5.

Distribution Abroad.

Germany (Kiefer, Klie, etc.).
Sweden (Lilljeborg).
Russia : Kostroma (Smirnov).
Holland : Friesland (R. G.).
North America : New Haven (Kiefer).

Bionomics.

C. varicans and *C. v. rubellus*. Both are summer forms. Whereas *C. varicans* occurs, generally singly or in small numbers, in weedy waters round the Norfolk Broads, the form which is distinguished here as *C. v. rubellus* is often found in considerable numbers in flooded marshes with a rich carpeting of moss. It is associated with *C.*

nanus. This form has appeared in an aquarium stocked with dried flotsam from Langmere (Norfolk), but whether from resting eggs or from dormant copepodids it was impossible to say.

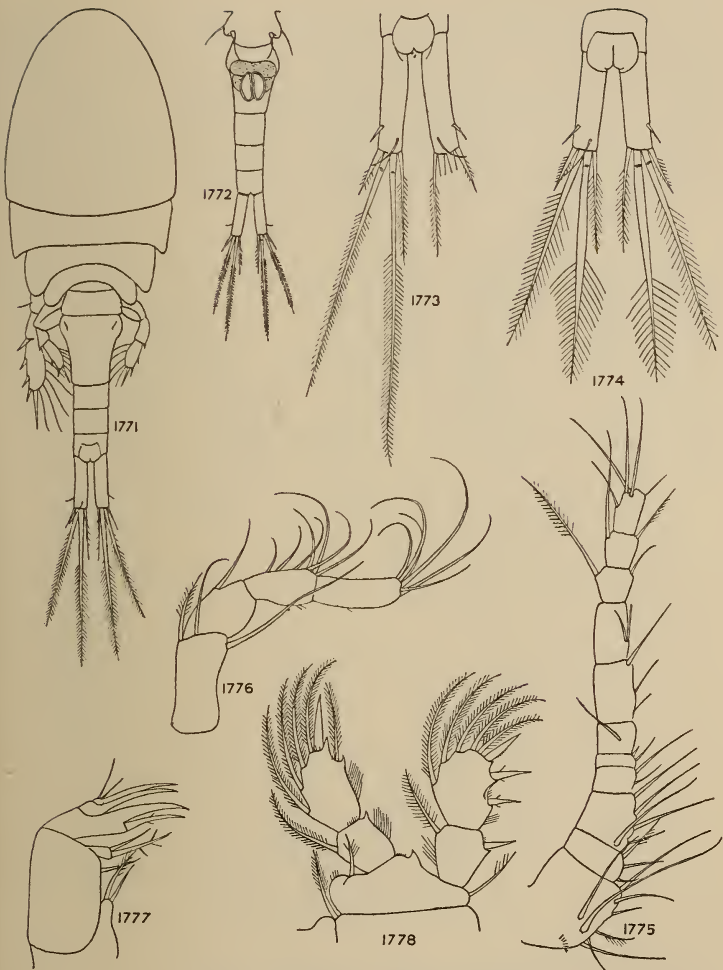
Cyclops bicolor, Sars.

(Figs. 1771–1784.)

1863. *C. bicolor*, Sars, Forh. Vid. Selsk. Christ. 1862, p. 253.
1874. *C. longicaudatus*, Poggenpol, Nachr. Ges. Moskau, X, p. 72, figs.
1880. *C. diaphanus*, Rehberg, Abh. Ver. Bremen, VI, p. 574.
1884. *C. brevisetosus*, *C. tenuicaudis*, Daday, Math. Term. Kozlem, XIX, pp. 255, 258, figs.
1892. *C. bicolor*, Schmeil, Bibl. Zool. XI, p. 118, figs.
1893. *Microcyclops bicolor*, Claus, Arb. Zool. Inst. Wien, X, p. 347.
1901. *C. bicolor*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 78, figs.
1913. ,, Sars, Crust. Norway, VI, p. 56, figs.
1929. *Microcyclops bicolor*, Kiefer, Tierreich, Lief. LIII, p. 70.
1930. *Cryptocyclops bicolor*, Lowndes, Proc. Zool. Soc. Lond. p. 174, figs.

Female.—Length ·6–·7 mm.

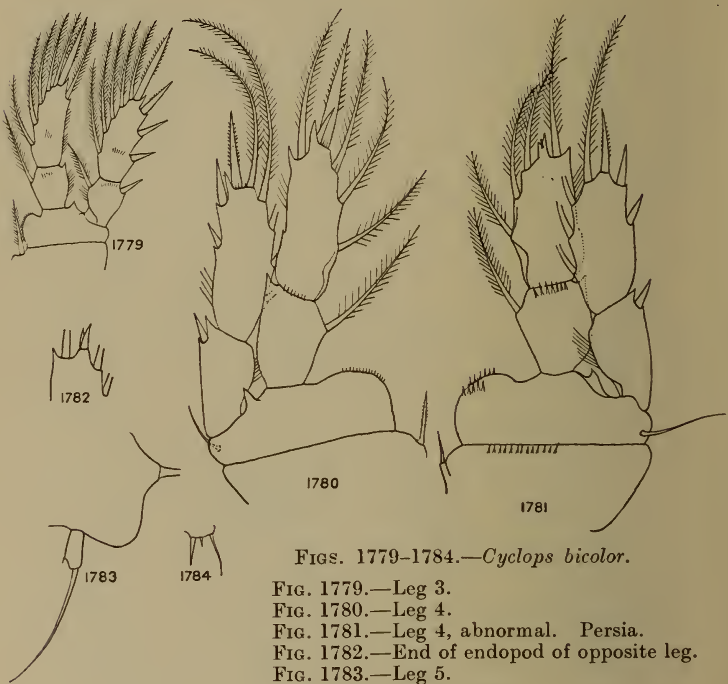
Body rather flattened; th. som. 5 with seta on either side; genital somite longer than wide, very protuberant ventrally; receptaculum with anterior part slightly concave in front, posterior part narrow, generally deeply indented. Furcal rami 4–5 times as long as wide, parallel; lateral seta inserted near end (75–80%); inner apical seta more than twice as long as outer, and nearly as long as ramus; setæ 2 and 3 short, often markedly swollen in basal half, and with rather coarse feathering. Antennule shorter than cephalothorax, of 11 segments, seg. 8 with slender æsthete closely apposed to the segment. According to Wolf seg. 3 may not be divided, so that the antennule has then only 10 segments. Legs with rami 2-segmented; spine formula 3.4.4.3. Leg 1 with inner seta of basis shorter than endopod 1. Basis of legs 2–4 with inner lobe bearing a double row of small spines. Leg 4 smaller than leg 3, directed outwards, and visible from above; exopod with outer spines very small; endopod 2, 2–2½ times as long as wide; inner apical spine shorter than segment; outer spine much reduced, about one-fifth of inner; distal setæ of endopod reaching to, or a very little beyond,



FIGS. 1771–1778.—*Cyclops bicolor.*

FIG. 1771.—Female, dorsal.
FIG. 1772.—Abdomen, ventral, showing receptaculum and spermatophores.
FIG. 1773.—Furcal rami.
FIG. 1774.—Furcal rami. Persia.
FIG. 1775.—Antennule, female.
FIG. 1776.—Antenna.
FIG. 1777.—Maxilla.
FIG. 1778.—Leg 1.

inner terminal spine. Leg 5, seg. 1 fused with th. som. 5, its seta borne at outer angle of latter; seg. 2 small and cylindrical, with long apical seta and small inner spine. This small spine is not mentioned by Sars or Schmeil, and is difficult to see, but it appears to be generally, if not always, present. Egg-sacs large, close to abdomen.



FIGS. 1779–1784.—*Cyclops bicolor.*

FIG. 1779.—Leg 3.
FIG. 1780.—Leg 4.
FIG. 1781.—Leg 4, abnormal. Persia.
FIG. 1782.—End of endopod of opposite leg.
FIG. 1783.—Leg 5.
FIG. 1784.—Leg 6, male.

Colour: Cephalothorax colourless or with blue spots, but antennules and abdomen a rich golden yellow.

Male.—Length ·5 mm.

Furcal rami shorter than in female, and inner apical seta very much longer. Antennule as in *C. varicans.* Leg 6 with large inner spine; middle seta reduced to a small spine; outer seta not much longer than inner spine.

C. varicans rubellus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of seg. 2.
1. Norfolk, Sutton .	·67	373	89	3·15	68	60	320	447	89	2·24	136	50
2.	·62	352	81	2·66	75	55	370	515	97	2·2	128	51
3. Norfolk, East Ruston	·63	332	79	3·2	68	55	300	440	78	2·72	133	67
4. ,, ,, .	·62	355	82	2·8	68	63	350	500	82	2·25	150	53
5. ,, ,, .	·53	360	85	3·0	67	60	337	470	85	3·0	133	67

C. bicolor.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of seg. 2.
1. Norfolk . . .	·65	..	104	3·9	73	49	230	245	104	2·8	350	83
2. ,, . . .	·68	337	116	4·55	76	44	250	322	103	2·15	460	77
3. ,, . . .	·65	322	124	4·8	78	54	255	323	115	2·65	600	85
4. ,, . . .	·575	345	115	4·3	69	52	245	..	104	3·13	360	72
5. ,, ♂ . .	·5	..	90	3·6	78	76	..	..	162	3·0	460	88
6. Ireland, Lough Derg	·6	348	116	4·65	73	48	237	..	84	2·77	400	92
7. Holland . .	·62	370	102	3·65	70	48	234	282	97	2·6	384	88
8. ,, ♂ . .	·44	..	101	3·36	74	72	380	510	186	3·14	..	92
9. Persia, Enzeli . .	·62	340	97	4·0	80	48	225	240	98	2·6	500	77

Distribution in Britain.

Scotland: Campbelltown, Cantyre (Scott).
Wales: Lake Ddinas, Maentwrog Moor (R. G.); Llyn Padarn (D. J. S.).
Ireland: Newport (D. J. S.); Lough Derg (R. G.).
England: Lake District (D. J. S., R. G.).
Norfolk: 22 localities in Broads district (R. G.).
Essex: Epping, etc. (D. J. S.).
Wiltshire: Marlborough (A. G. L.).
Kent: Minster (D. J. S.).

Distribution Abroad.

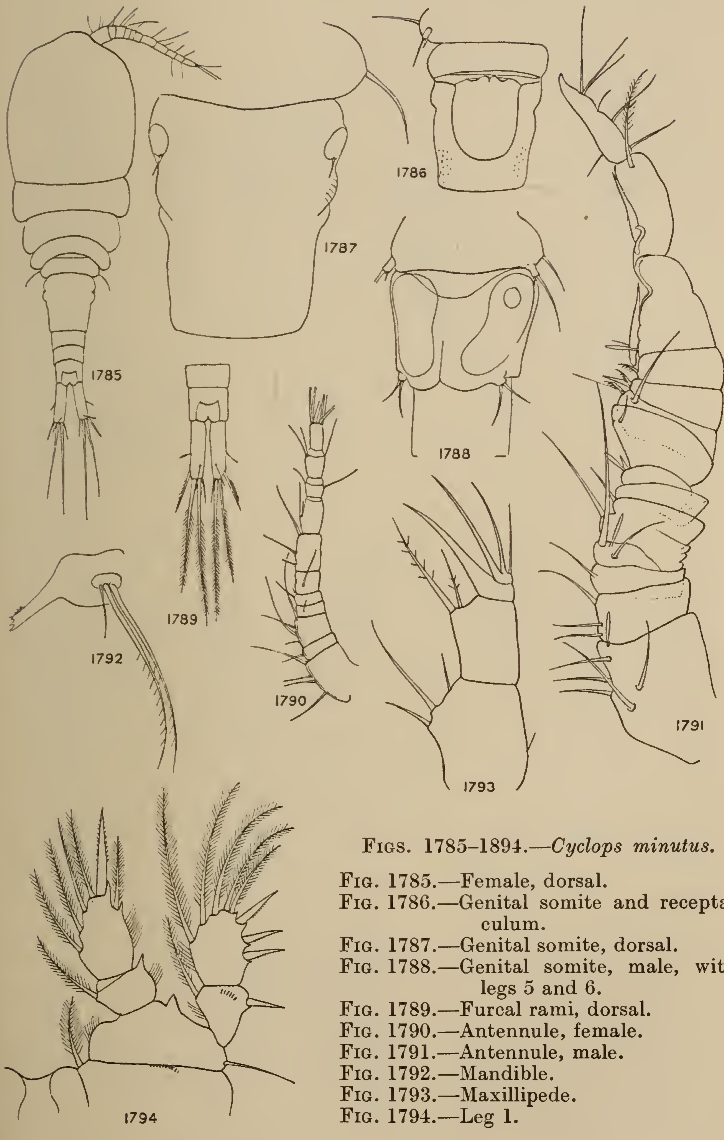
Europe: Generally distributed.
Asia: Sumatra, Java (Daday); Amur Region (Smirnov); Manchuria (Rylov); India (R. G.); Persia (R. G.).
Africa: Egypt (Chappuis, R. G.); East Africa (Daday); Abyssinia (A. G. L.); N. Nigeria (R. G.).
North America (Marsh).
New Hebrides (A. G. L.).

Cyclops minutus, Claus.

(Figs. 1785–1800.)

? 1853. *C. diaphanus*, Fischer, Bull. Soc. Mosc. XXVI, 1, p. 93, figs.
1863. *C. minutus*, Claus, Freileb. Cop. p. 102, figs.
1892. *C. longicaudatus*, Brady, Trans. N. H. Soc. Northd. XI, p. 88, figs.
1892. *C. diaphanus*, Schmeil, Bibl. Zool. XI, p. 112, figs.
1893. ,, Richard, Rev. Biol. Nord. Fr. Ann. V, p. 404, figs.
1894. ,, Claus, Arb. Inst. Wien, XI, p. 1, figs.
1921. ,, Gurney, J. Bombay N. H. Soc. XXVII, p. 90.
1922. *C. minutus*, Thallwitz, Zool. Anz. LIV, p. 263.
1926. ,, Kiefer, Int. Rev. Hydrob. XIV, p. 357, figs.
1926. *C. diaphanus*, Marsh, Voyage zool. Gadeau de Kerville, I, p. 179, figs.
1927. *C. minutus*, Gurney, Ann. Nat. Hist (9), XIX, p. 506, figs.
1929. ,, Kiefer, Tierreich, Lief. LIII, p. 74.

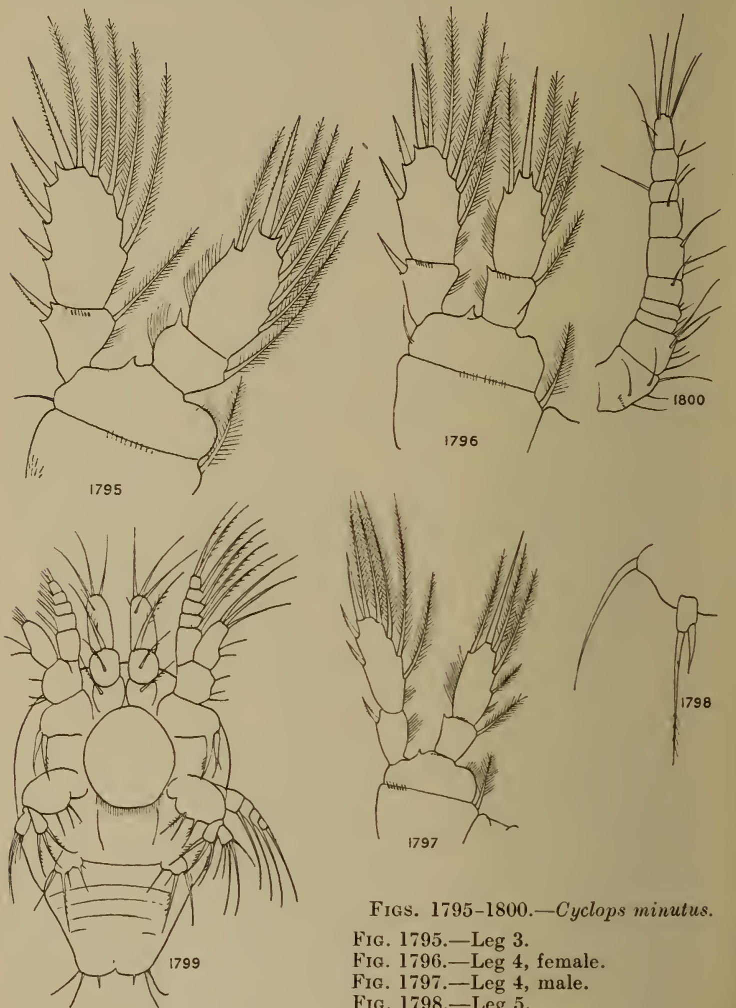
The species here described was identified by Schmeil and others with *C. diaphanus*, Fischer. The first adequate description was given by Claus under the name of *C. minutus*, but Claus himself later regarded his species as synonymous with that of Fischer.



FIGS. 1785–1894.—*Cyclops minutus.*

FIG. 1785.—Female, dorsal.
FIG. 1786.—Genital somite and receptaculum.
FIG. 1787.—Genital somite, dorsal.
FIG. 1788.—Genital somite, male, with legs 5 and 6.
FIG. 1789.—Furcal rami, dorsal.
FIG. 1790.—Antennule, female.
FIG. 1791.—Antennule, male.
FIG. 1792.—Mandible.
FIG. 1793.—Maxillipede.
FIG. 1794.—Leg 1.

Lilljeborg, however, introduced real confusion by transferring Fischer's name to *C. nanus*, Sars, and by



FIGS. 1795-1800.—*Cyclops minutus.*

FIG. 1795.—Leg 3.
FIG. 1796.—Leg 4, female.
FIG. 1797.—Leg 4, male.
FIG. 1798.—Leg 5.
FIG. 1799.—Nauplius stage IV.
FIG. 1800.—Antennule, female, copepodid 4.

giving *C. minutus* as a synonym of it. Sars followed Lilljeborg's example. Now, *C. minutus* is quite

obviously neither the same species as *C. nanus*, nor even closely related to it, and, whether it is synonymous or not with *C. diaphanus*, Fischer, the latter name must be dropped, as the clear meaning which was attached to it by Schmeil has been taken away by Lilljeborg.

Female.—Length ·83–1·06 mm.

Th. som. 5 rounded at outer angles, and with lateral seta. Genital somite longer than wide, not much dilated, and with lateral incision about middle; receptaculum with posterior part only developed, large and oval. Cuticle throughout generally pitted. Furcal rami 4–5 times as long as wide; lateral seta inserted at, or just beyond, middle; inner apical seta shorter than outer, and about half length of ramus. Antennule of 11 segments, much shorter than cephalothorax. Legs with rami 2-segmented; spine-formula 3.4.4.3. Leg 1 basis without inner seta. Legs 1–3 with inner seta on exopod 1. Leg 4 smaller than leg 3, and endopod shorter than exopod; exopod 1 without inner seta; outer seta of basis very small; endopod 2 generally more than $2\frac{1}{2}$ times as long as wide, and with one apical spine only, which is a little longer than the segment: setæ of this segment not extending beyond spine. Leg 5 of one free segment, the basal segment entirely absorbed in the somite, and its seta inserted on outer edge of the latter. The single free segment very small, about $1\frac{1}{2}$ times as long as wide, with apical seta and a stout subapical spine longer than the segment. Egg-sacs rather large, not divergent.

Male.—Length ·7–·92 mm.

More slender than female in all respects; furcal rami and setæ longer. Antennule of 17 segments, the æsthetes exceedingly small, seg. 1, in a number of specimens examined, with one æsthete only instead of the usual 3. Legs more slender than in female; leg 4, endopod 2 more than twice as long as wide, and apical spine more than $1\frac{1}{2}$ times as long as segment. Leg 6 with 2 spines only.

C. minutus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 2.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
1. Coverack, Cornwall, ♀	·9	365	104	4·0	56	68	188	263	50	1·45	..	130
2. ,, ,, ♀	·91	330	100	3·62	52	60	183	250	41	1·5	..	110
3. ,, ,, ♂	·70	300	128	4·15	58	90	242	390	73	2·3	..	176
4. Marlborough, ♀ .	·83	325	104	3·75	60	72	230	325	50	2·17	..	176
5. ♀ .	·87	310	113	3·85	55	68	223	322	48	2·0	..	120
6. Tunis (1), ♀ . .	·94	340	103	4·0	52	64	212	270	32	1·84	..	126
7. ,, ♂ . .	·91	252	115	4·85	62	88	220	..	55	2·42	..	160
8. Tunis (2), ♀ . .	1·06	320	92	3·85	55	71	..	252	47	1·75	..	134
9. ,, ♂ . .	·92	250	104	4·7	60	88	206	315	54	2·6	..	160
10. ,, Copepodid IV	·66	..	90	2·18	50	75	196	365	53	1·65	..	165

Cyclops gracilis.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 2.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
1. Norfolk, ♀ . . .	·74	325	83	3·33	48	49	188	242	83	3·1	680	142
2. ,, ♂ . . .	·63	238	78	3·22	45	40	190	220	76	3·25	450	154
3. Naardermeer, Holland, ♀	·63	..	95	2·9	48	49	206	252	81	3·1	440	142

Distribution in Britain.

Wiltshire: Near Salisbury (Brady); Marlborough (A. G. L.).
Norfolk: Near Norwich (D. J. S.); Brunstead (R. G.).
Cornwall: Coverack (R. A. Todd).
Sussex: East Dean (D. J. S.).
Westmoreland: Near Coniston (R. G.).
Pembrokeshire: St. David's (D. J. S.).

Distribution Abroad.

Europe: Germany (Wolf, etc.); Bulgaria (Chickoff); Portugal (De Guerne and Richard); Russia (Smirnov).
Asia: Kara-Kum desert (Smirnov); Palestine and Syria (Richard, Marsh, R. G.); Mesopotamia (R. G.); Sinai (Chappuis); India (R. G.).
Africa: Algeria and Tunisia (R. G., Roy and Gauthier); Cyrenaica (R. G.); Egypt (R. G.); German S.W. Africa (Van Douwe).

Bionomics.

The commonest species in Algeria and Tunisia in small muddy pools and ditches which dry up in summer, and these surroundings seem to be characteristic of it throughout its range. In this country such temporary pools are exceptional, and the species is exceedingly rare. The specimens from Coverack were taken in a shallow muddy pool which would probably dry up later, and those from Norfolk were from a puddle and a flooded marsh. On the other hand, it is probable that the mossy pool near Coniston in which it was found would never dry up. Mr. Scourfield has taken it in a duckpond at East Dean two years in succession—in this case the only *Cyclops* present. That the species is able to survive desiccation is shown by its hatching from dried mud (Claus, 1894). I have seen it appear in an aquarium stocked with dried mud from Palestine. Claus established the fact that the animal appears first in copepodid stages, and not as a nauplius.

Cyclops gracilis, Lilljeborg.

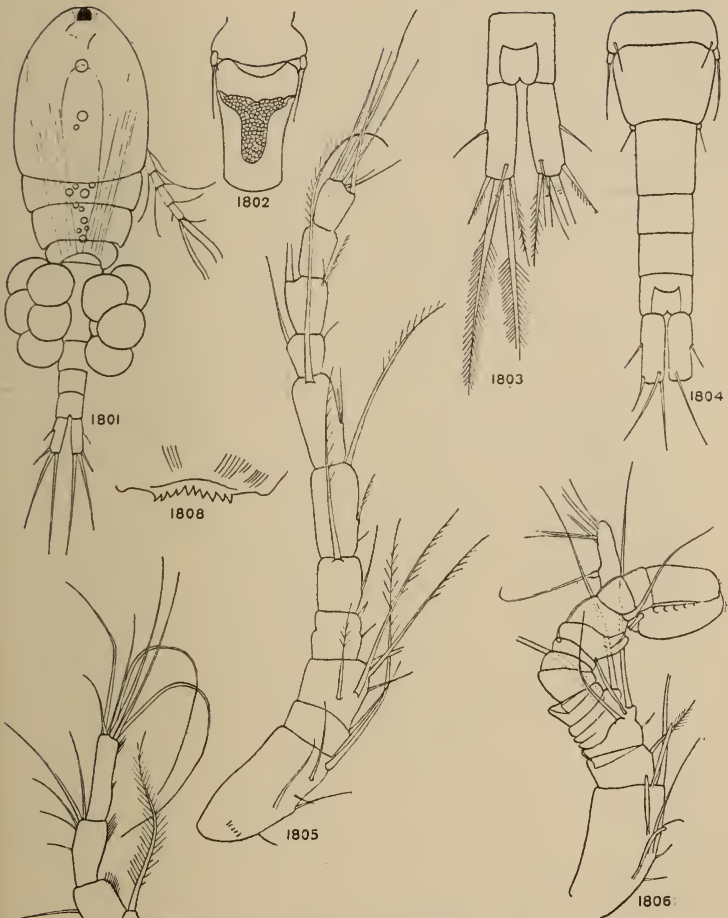
(Figs. 1801–1817.)

1853. *C. gracilis*, Lilljeborg, Crust. Ord. Trib. p. 208.
1890. ,, Lande, Pam. Fizyjogr. Warsaw, X, p. 71, figs.
1892. ,, Schmeil, Bibl. Zool. XI, p. 110, figs.
1893. *Microcyclops gracilis*, Claus, Arb. Inst. Wien, X, p. 347, figs.
1901. *C. gracilis*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 69, figs.
1907. ,, V. Breemen, Tijds. Ned. Ver. (2), X, p. 344, figs.
1914. *Mesocyclops gracilis*, Sars, Crust. Norway, VI, p. 63, figs.
1927. *Metacyclops gracilis*, Kiefer, Zool. Anz. LXXIII, p. 308.
1929. ,, ,, Kiefer, Tierreich, Lief. LIII, p. 72.

Female.—Length ·78–·82 mm.

Body slender, greatest width in mandibular region ; th. som. 5 not wider than genital somite, rounded laterally. Abdomen very slender, two-thirds as long as thorax ; genital somite long and slender, greatest width not much more than half length. Receptaculum hammer-shaped, the posterior part long and narrow. Furcal rami rather divergent,* about 3 times as long as wide, the lateral seta inserted in, or in front of, middle ; inner apical seta shorter than ramus, and considerably longer than outer one ; seta 3 rather short, about one-fifth length of body, finely feathered. Antennules slender, reaching beyond th. som. 2, and of 11 segments. Segs. 7 and 8 very long and slender ; æsthete in middle of seg. 8, long and slender. Swimming-legs with rami 2-segmented ; spine-formula 3.4.4.3. Uniting lamella of leg 1 with rather prominent lobes ; these lobes smaller in legs 2 and 3, and absent in leg 4. Leg 1 with very long outer seta on basis, and slender inner spine reaching beyond seg. 1 of endopod. Leg 4, exopod 1 without inner seta ; endopod 2 very slender, the inner apical spine longer than segment ; outer spine minute ; setæ not reaching end of apical spine. Leg 5 of 1 free segment, seg. 1 represented only by its seta, attached to outer margin of somite ; seg. 2 slender, cylindrical, with apical seta and a minute inner apical spine. Egg-sacs small, with few eggs, close-pressed to abdomen.

* The rami are distinctly movable in life.

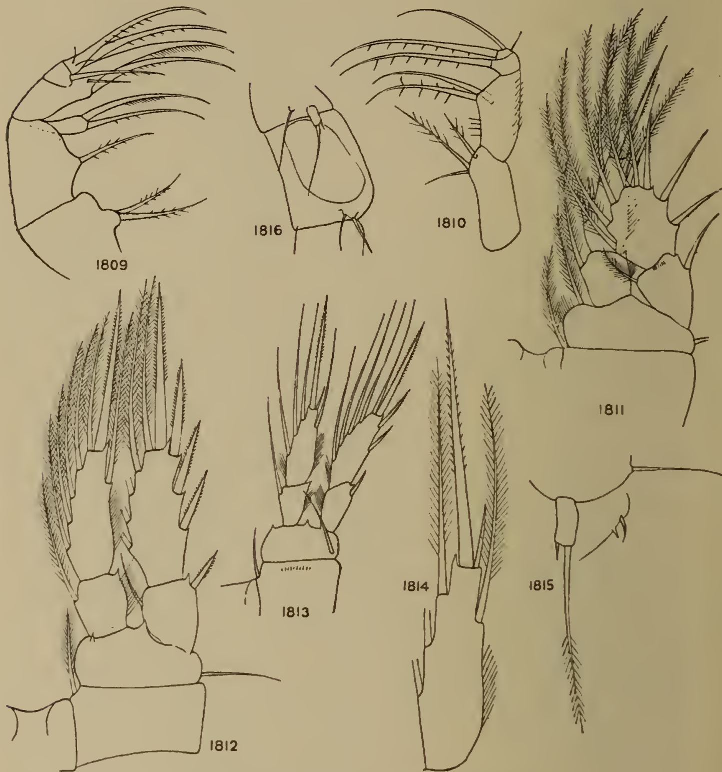


Figs. 1801–1808.—*Cyclops gracilis.*

Fig. 1801.—Female, dorsal.
Fig. 1802.—Genital somite and receptaculum.
Fig. 1803.—Furcal rami, dorsal, female.
Fig. 1804.—Abdomen, male, dorsal.
Fig. 1805.—Antennule, female.
Fig. 1806.—Antennule, male.
Fig. 1807.—Antenna.
Fig. 1808.—Labrum.

Colour rosy red, antennule and rami particularly richly coloured.

Male.—Length ·63 mm.



FIGS. 1809–1816.—*Cyclops gracilis.*

FIG. 1809.—Maxilla.
FIG. 1810.—Maxillipede.
FIG. 1811.—Leg 1.
FIG. 1812.—Leg 3.
FIG. 1813.—Leg 4.
FIG. 1814.—Leg 4, endopod 2.
FIG. 1815.—Leg 5, female.
FIG. 1816.—Legs 5 and 6, male.

Antennule of 17 segments, with normal number of rather long æsthetes ; seg. 15 slightly ribbed on inner side. Leg 6 with a single rather long inner spine and a short outer seta.

Nauplius.

The nauplius is of unusual form, being much constricted behind, and with very prominent furcal lobes, each bearing a stout apical spine. Exopod of antenna of 5 segments, segs. 2–4 approximately equal. There is a ventral row of hairs on either side in the mandibular region.

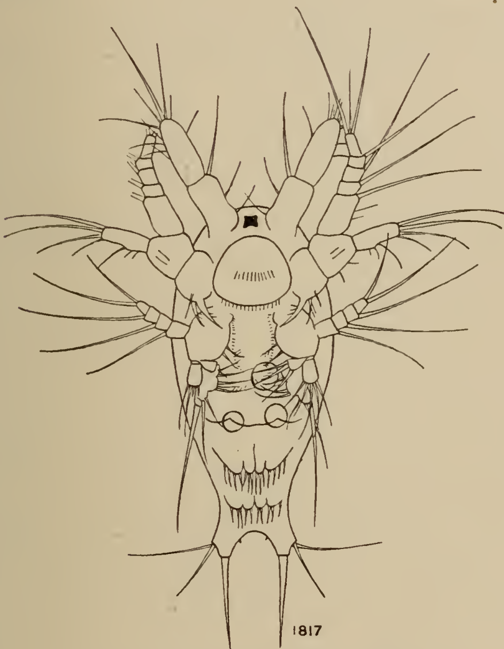


Fig. 1817.—*Cyclops gracilis*, nauplius VI.

Distribution in Britain.

Norfolk, Larling Heath. I found this species first in a small pond on Larling Heath on May 28th, 1927, and later in another adjacent pond. There are a number of small ponds here, occupying depressions in the chalk, and generally containing much *Potamogeton*, etc. In these two only has *C. gracilis* been found. It is worth noting that one of them is also the only place in Britain

in which the Cladoceran *Echinisca tenuicornis* (Kurz) has been taken.

Distribution Abroad.

Europe: Sweden (Lilljeborg); Norway (Sars); Germany (Schmeil, etc.); Holland (v. Breemen, R. G.); Hungary (Daday); Bulgaria (Chickoff); Russia (Smirnov); Switzerland (Graeter).

Asia: Mongolia (Daday).

S. America: Argentine (Mrázek).

Bionomics.

Wolf (1905, p. 169) gives an account of his observations, which show peculiar irregularity in appearance. For example, in one pond it was found on May 22nd in numbers, the females bearing eggs, although it had certainly not been present 8 days before. Wolf concluded that it must have been dormant in the mud in the adult condition. In this pond adults disappeared entirely between June 24th and July 22nd, but a new generation reached a maximum on September 1st. By September 14th all had again disappeared. He concluded that it is exclusively a summer form, and that the last generation, in this case the third, passes the winter in the mud. My own observations are confined to eight visits during three years. The species has not been found adult before the end of May, and only once in real abundance (June 6th). On this occasion very few had eggs, and the species entirely disappeared in September. So far as these observations go, it does not seem to have a second generation in late summer. On my last visit (21.iv.29) only nauplii and copepodid stages were found, which seems to indicate the production of resting eggs, rather than hibernation in adult or copepodid stages.

Cyclops unisetiger-Group.

Brehm (1926) included *C. unisetiger* with *C. racovitzai*, Chapp., *C. troglodytes*, Chapp., and *C. operculatus*,

Chapp., in a new genus *Graeteriella*, of which the distinguishing character was the possession of an operculum. Kiefer (1928, p. 524) has rightly shown that this character alone is of no value, since the operculum may be more or less prominent in other species, and there are species apparently related to *C. unisetiger* in which it is inconspicuous. A number of species have now been described from underground waters in Europe, and from moss in South America and Java, which agree with *C. unisetiger* either in having a large operculum, or in the reduction of the legs and other respects, and it is most difficult to place them satisfactorily. Chappuis (1927B, p. 134) considered it possible that the European subterranean forms might be Tertiary relicts of a tropical fauna, and related to the more or less similar forms now living in moss in America and Java. Kiefer, while placing the South American forms close to *C. unisetiger*, founded a new genus, *Bryocyclops*, for the five species from Java and the New Hebrides. The only common character of the latter is the complete absorption of leg 5 into the somite, and this seems to be only an extension of the process of reduction already at work in *C. unisetiger*. Since *C. racovitzai*, Chapp., which Kiefer includes in *Diacyclops*, has almost the same form of leg 5 as *C. anninæ*, Menzel, for instance, there seems to be no ground for separating them. All these forms do, in fact, seem to be a related series which it would be convenient to separate under a subgeneric name, but it does not seem possible to find any clear common characters by which such a group can be defined. Kiefer suggests that the European forms are related, through *C. stygius*, Chapp., to the *C. languidus* group. If they are to be treated as a subgenus *Graeteriella*, Brehm would be a valid name for it, if the definition is amended.

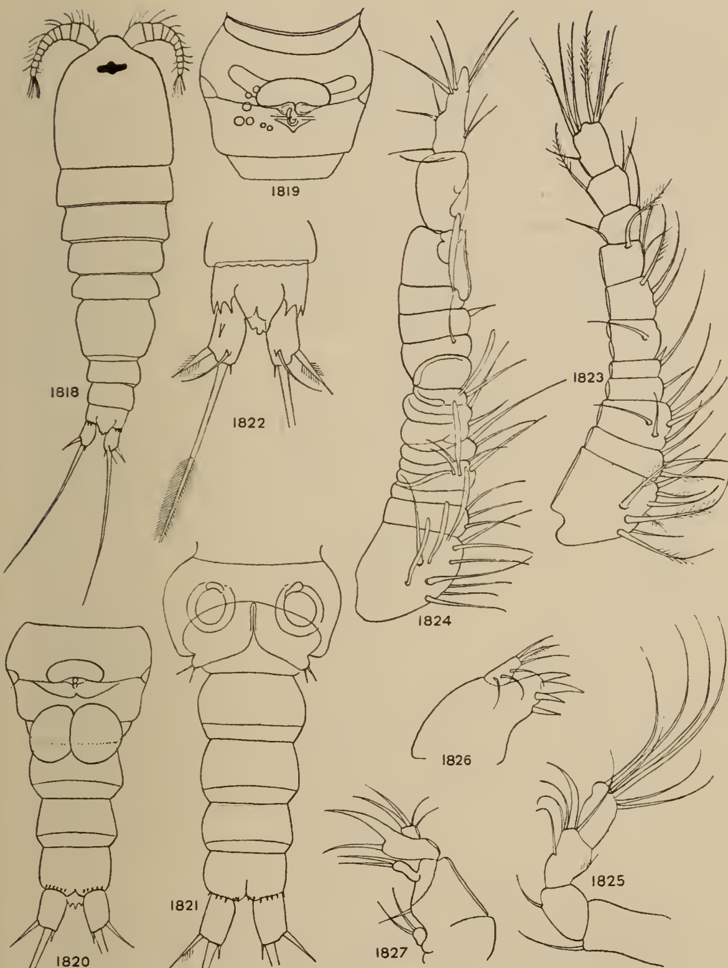
Cyclops unisetiger, E. Graeter.

(Figs. 1818–1835.)

1908. *C. unisetiger*, E. Graeter, Zool. Anz. XXIII, p. 49.
1910. ,, E. Graeter, Arch. Hydrob. VI, p. 44, figs.
1923. ,, Chappuis, Bull. Soc. Cluj. I, p. 585, figs.
1926. *C. u.* forma *biarticulata*, Kiefer, Schr. Ver. Donaueschingen, XVI, p. 277, figs.
1928. ,, ,, Kiefer, Zool. Jahrb. LIV, p. 526, figs.

Female.—Length ·37–·52 mm.

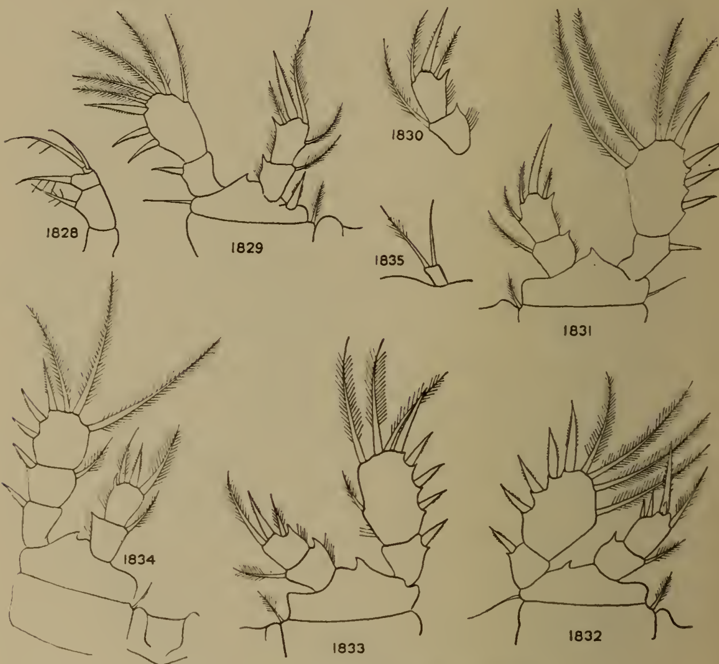
Body rather flattened, with deep indentations between somites. Th. soms. 4 and 5 scarcely broader than genital somite, so that thorax is not sharply marked off from abdomen. Operculum very large, triangular, with 3 blunt teeth at apex. Furcal rami about twice as long as wide; lateral seta spine-like, inserted on dorsal side in front of middle; dorsal seta nearly as long as ramus; inner apical seta very small; one of the two middle setæ absent, the remaining seta about one-third length of body. Genital somite broader than long; receptaculum rather variable, apparently without posterior part, the anterior part generally rather kidney-shaped, but often with lateral extensions. One specimen seen with a pair of large transparent vesicles attached to somite (Fig. 1820) but without any visible connection with receptaculum, which was almost invisible. In rolling the animal over the vesicles disappeared, but the receptaculum then appeared quite clearly. It is probable that the vesicles were spermatophores, the contents of which were drawn into the receptaculum by pressure. Som. 5 with posterior row of spines, very large dorsally. Eye large, black, of peculiar transversely elongated form. Antennule of 11 segments, reaching back about half-way along cephalothorax; seg. 8 with æsthete reaching to end of seg. 9. Antenna with seg. 4 shorter than seg. 3. Mandible with 2 short setæ representing palp. Maxillæ and maxillipedes of normal form, but the latter apparently with only 4 setæ. Legs with endopods 2-segmented, and exopods of legs 1–3 of 2 segments. In leg 4 the exopod may be either



FIGS. 1818–1827.—*Cyclops unisetiger.*

FIG. 1818.—Female, dorsal.
FIG. 1819.—Genital somite and receptaculum.
FIG. 1820.—Abdomen, ventral, showing spermatophores.
FIG. 1821.—Abdomen, male, ventral.
FIG. 1822.—Operculum and furcal rami, dorsal.
FIG. 1823.—Antennule, female.
FIG. 1824.—Antennule, male.
FIG. 1825.—Antenna.
FIG. 1826.—Maxillule.
FIG. 1827.—Maxilla.

2* or 3-segmented; all females seen had 2 segments, but a male had 3. Exopod 1 without inner seta; exopod 2 with 3.4.4.4 spines and 5.4.4.4 setæ. Leg 4, endopod 2 with 2 setæ and a median apical spine. Leg 5 without any trace of seg. 1, even the seta commonly



FIGS. 1828–1835.—*Cyclops unisetiger.*

FIG. 1828.—Maxillipede.
FIG. 1829.—Leg 1, male.
FIG. 1830.—Leg 2, endopod, male.
FIG. 1831.—Leg 3, male.
FIG. 1832.—Leg 3, female.
FIG. 1833.—Leg 4, female.
FIG. 1834.—Leg 4, male.
FIG. 1835.—Leg 5.

representing it being absent; the single small segment bears 2 apical setæ which may be of equal length, or, more commonly, the inner one much the shorter. Leg 6 represented by 2 minute spines. Egg-sacs not seen.

Colourless.

* Forma *biarticulata*, Kiefer.

Male.—Length ·38–·45 mm.

Genital somite very broad ; leg 6 with 2 small spines. Antennule with large æsthetes on segs. 1, 4, 9, 13 ; terminal part very short and stout.

Distribution.

Switzerland : Grotte de Vert, Jura (Graeter) ; Grotte de Vert and Grotte du Chemin de Fer, gorges de l'Areuse, near Neuchâtel ; springs near Bâle (Chappuis).

Germany : Water-pipes at Öfingen (Kiefer) ; Bad Pyrmont (Klie).

Britain : I have found this species in two places : (1) In wet peat on the slope of Boars Hill, Oxford. (2) In a culture from moss taken off a wet rock face at Tall-y-Llyn, North Wales. None were found in the original examination, but a few appeared some months later. At Oxford only females were taken, but the Welsh colony included a few males.

Bionomics.

As Graeter observed, the animal has, not only in its appearance, but also in its manner of movement, a striking likeness to a Harpacticid. Its movements are active, but aimless and erratic. It has only been found abroad in caves or spring waters, but in this country hitherto in surface-water.

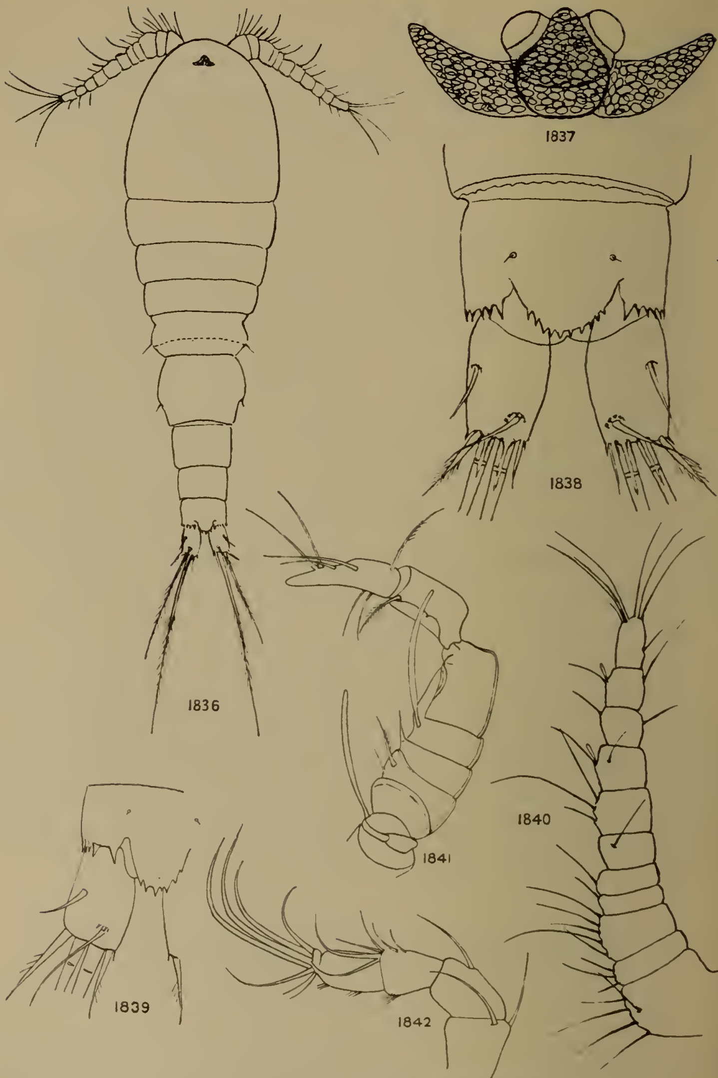
Cyclops demetiensis, Scourfield.

(Figs. 1836–1852.)

1932. *C.* (*Bryocyclops*) *demetiensis,* Scourfield, Ann. Mag. Nat. Hist. (10) X, p. 559, figs.

Female.—Length ·5 mm.

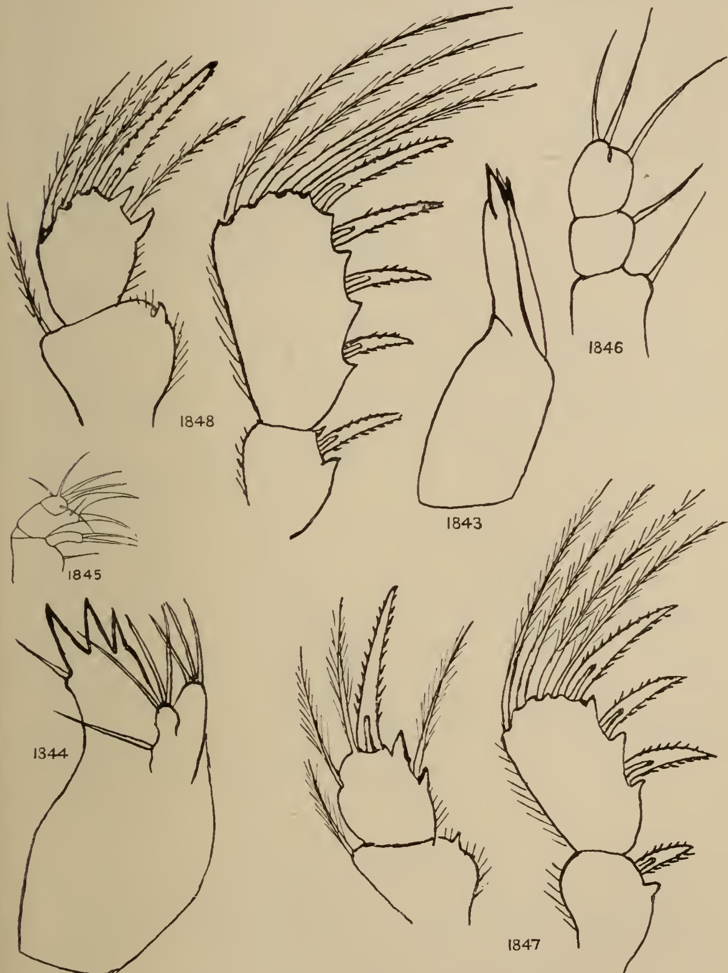
Body tapering almost evenly from cephalothorax to furca, the general appearance approaching the Harpacticid type. Som. 5 nearly as wide as som. 4, and genital somite nearly as wide as th. som. 5, wider than



FIGS. 1836–1842.—*Cyclops demetiensis.*

FIG. 1836.*—Female, dorsal.
FIG. 1837.*—Eye.
FIG. 1838.*—Furcal rami, dorsal, female.
FIG. 1839.—Furcal rami, male.
FIG. 1840.*—Antennule, female.
FIG. 1841.—Antennule, male, distal part.
FIG. 1842.—Antenna.

long; receptaculum with large oval anterior part, surrounded by a hyaline area, the posterior part reduced

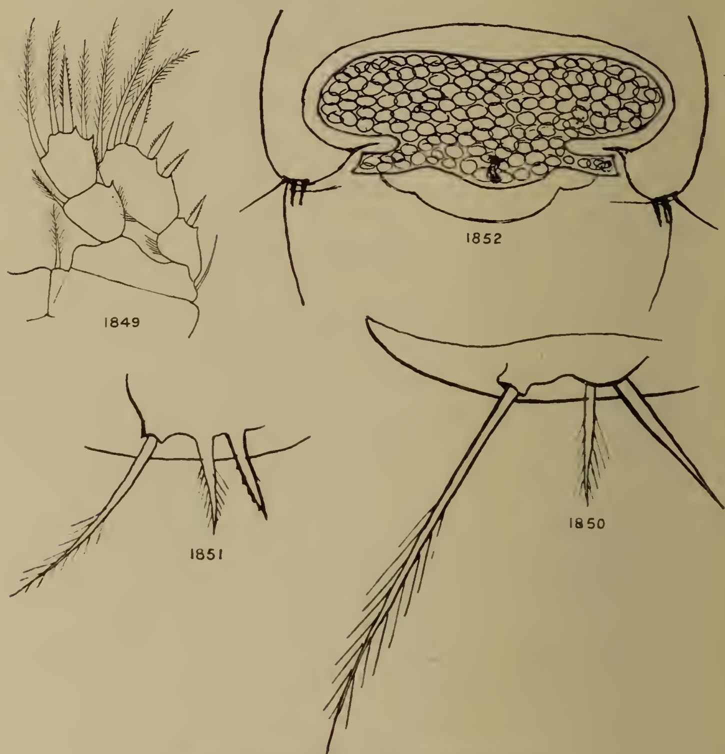


Figs. 1843–1848.—*Cyclops demetiensis.*

Fig. 1843.*—Mandible.
Fig. 1844.*—Maxillule.
Fig. 1845.—Maxilla, distal part.
Fig. 1846.*—Maxillipede.
Fig. 1847.*—Leg 1.
Fig. 1848.*—Leg 3.

to a very narrow band, giving appearance of two small horns. Abd. som. 5 with posterior fringe of denticles,

those adjacent to the operculum the largest ; operculum large, semicircular or slightly elongated, and bordered with teeth variable in size, number and position. Rami a little longer than broad, without dorsal ridge ; lateral



FIGS. 1849–1852.—*Cyclops demetiensis.*

FIG. 1849.—Leg 4. FIG. 1851.*—Leg 6, female.
FIG. 1850.*—Leg 5, female. FIG. 1852.*—Receptaculum.

Figs. marked * after D. J. Scourfield.

seta slightly on dorsal side, a little in front of middle ; inner apical seta shorter than outer ; seta 3 very much longer than seta 2. Eye red, surrounded by a tripartite mass of blackish granules, one cusp of which is dorsal, and the other two obliquely ventral. Antennule of

11 segments, with æsthetes on segs. 8 and 10. Mandibles without trace of palp. Maxillipedes reduced, of 3 segments, the apical segment with 3 setæ. Swimming-legs with rami of 2 segments; endopod seg. 1 with inner seta; seg. 2 with apical spine and 2 inner setæ in legs 1, 2 and 4, but 3 in leg 3. Exopod seg. 1 without inner seta; exopod 2 with spines and setæ thus:

	Leg 1.	Leg 2.	Leg 3.	Leg 4.
Spines	3	4	4	3
Setæ	4	4	4	3

Spines solid, except for a short basal lumen. Leg 5 represented by a narrow ridge bearing an inner spine and two setæ, of which the outer is very long and the inner is shorter than the spine. Leg 6 unusually well developed, and closely resembling leg 5.

Colour white.

Egg-sacs not seen.

Male.—Length ·48 mm.

Antennule of normal form, with 3 long æsthetes on seg. 1, and one each on segs. 4, 9 and 13. Leg 6 as in female, but slightly more developed.

Nauplius ovoid; eye divided into two small red spots. Exopod of antenna well developed, with 5 or 6 segments, the terminal segments about equal.

Occurrence.

Taken by Mr. Scourfield, in June, 1927, and September, 1930, in greenish earthy material scraped from the cliff face of the North Bay at Tenby, where a small trickle of water issued from a fissure in the rocks. It was found at no other place, and Mr. Scourfield concludes that it may be of subterranean origin. The movements are active, generally creeping, but it is able to swim with quick zig-zag motion resembling that of a Harpacticid. It has a tendency to creep out of water. From the fact

that nauplii were found in a bottle containing the adults, while the latter were never seen with egg-sacs, it seems probable that the eggs are laid free.

This species is referred by Mr. Scourfield to the genus (treated by him as a subgenus) *Bryocyclops*, Kiefer, which is founded, mainly upon the form of leg 5, to receive 5 species from Java and the new Hebrides. Reasons are given above (p. 277) for not accepting this subgenus or genus. The discovery of a species of the *Bryocyclops* group in Britain removes the geographical basis from the genus.

Subgenus **MESOCYCLOPS**, Sars.

1903. *Bifida Chætophora*, Graeter, Rev. Suisse Zool. XI, p. 471.
1914. *Mesocyclops*, Sars, Crust. Norway, VI, p. 57.
1928. ,, Kiefer, Zool. Jahrb. Syst. LIV, p. 552.
1930. ,, Kiefer, Zool. Anz. XC, p. 89 (key to species).

Furcal rami generally short, rarely with hairs on inner margin; inner seta usually long; antennule of 17 segments, with hyaline membrane on segs. 16, 17; swimming-legs with rami 3-segmented; leg 5 of 2 segments, seg. 2 with apical seta and long terminal or subterminal inner seta or spine. Receptaculum hammer-shaped.

Type.—*C. leuckarti*, Claus.

The subgenus is a large one, of which the species are largely tropical. In Kiefer's revision of 1929 he included 16 species, but added 4 more in an appendix. His key of 1930 contains 23 species, and there are now (October, 1932) 35 species described. The majority are distinguished by indefinable differences in the form of the receptaculum, which, in other subgenera, is admitted to be variable within rather wide limits.

Kiefer has divided his genus *Mesocyclops* into two subgenera, *Mesocyclops* s. str. and *Thermocyclops*, Kiefer, the latter containing the majority of the species. The distinguishing character is the position of the inner seta or spine on leg 5. In the former it is on the inner

side, near the apex, while it is apical in the latter. The species of *Mesocyclops*, s. str., are, on the whole, larger and stouter, while those of *Thermocyclops* are of more slender build and more often limnetic. It may be admitted that there may be two subgroups, but they do not, in my opinion, require separation, and the sole distinguishing character is so trivial as to be almost inapplicable. For instance, Kiefer includes in *Thermocyclops M. oblongatus*, Sars, in which the inner spine of leg 5 is figured by Sars in precisely the same position as that of *M. major*, Sars, which Kiefer regards as a synonym of *Mesocyclops* (s. str.) *leuckarti*.

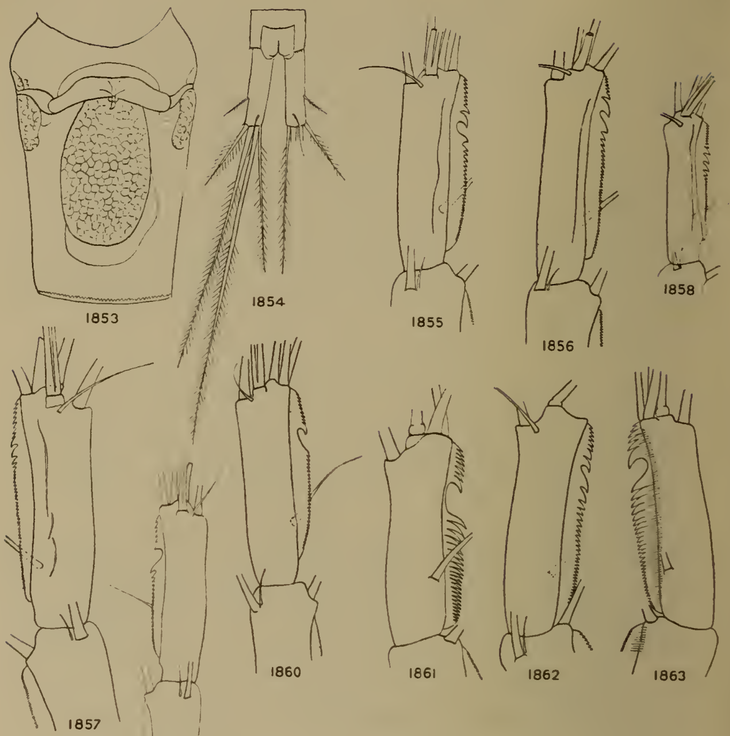
Key to the British Species of the Subgenus Mesocyclops.

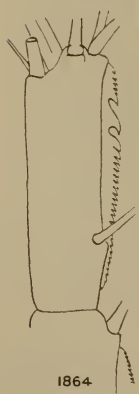
1. Leg 1, basis without inner seta ; antennule seg. 17 with hyaline membrane toothed . . . *C. leuckarti*.
   Leg 1, basis with inner seta ; antennular membrane without teeth . . . . 2.
2. Inner furcal seta more than twice as long as outer seta . 3.
   This seta not much longer than outer . . *C. dybowskii*.
3. Inner apical spine of leg 4 endopod 3 much longer than endopod 3 . . . . . . (*C. oithonoides*.)
   This spine shorter than endopod 3 . . . *C. hyalinus*.

Cyclops leuckarti, Claus.

(Figs. 1853–1879.)

1857. *C. leuckarti*, Claus, Arch. Naturg. XXIII, i, p. 35, figs.
1874. *C. simplex*, Poggenpol, Nachr. Ges. Moskau, X, p. 70, figs.
1878. *C. leeuwenhoeki*, Hoek, Tijdschr. Ned. Dierk. Ver. III, p. 19, figs.
1884. *C. pectinatus*, Daday, Math. Term. Koz. XIX, p. 223, figs.
1889. *C. lucidus*, Russki, Trudy Kasan Univ. XIX, p. 27, figs.
1892. *C. scourfieldi*, Brady, Trans. N. H. Soc. Northd. XI, p. 75, figs.
1892. *C. leuckarti*, Schmeil, Bibl. Zool. XI, p. 57, figs.
1906. *C. aspericornis*, Daday, Zool. Jahrb. XXIV, p. 181, figs.
1908. *C. l.* var. *australiensis*, Sars, Arch. Naturv. Christ. XXIX, p. 16, figs.
? 1909. *C. albicans*, Smith, Trans. Linn. Soc. (2), XI, p. 89, figs.
1909. *C. pulchellus*, Byrnes, Cold Spring Harb. Mon. No. 7, p. 24, figs.
1914. *Mesocyclops obsoletus*, Sars, Crust. Norway, VI, p. 58, figs.
1925. *C. monardi*, Perret, Zeits. Hydrol. III, p. 41, figs.
1927. *M. major*, Sars, Ann. S. Afr. Mus. XXV, p. 116, figs.
1929. *M. leuckarti*, *M. l. æquatorialis*, *M. l. bodanicola*, Kiefer, Zeits. wiss. Zool. CXXXIII, pp. 4, 17, figs.
1930. *M. l.* forma *pilosa*, Kiefer, Zool. Anz. LXXXVII, p. 46, figs.
? 1930. *M. annæ*, Kiefer, *ibid.*, p. 46, figs.
1931. *M. thermocyclopoides*, Harada, Annot. Zool. Japon. XIII, p. 161, figs.





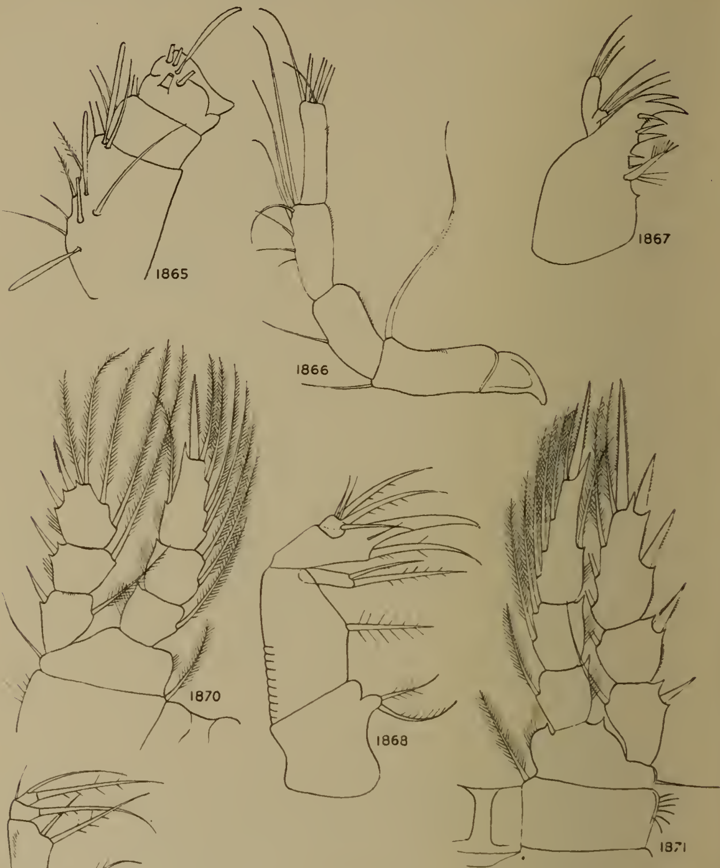
FIGS. 1853–1864.—*Cyclops leuckarti.*

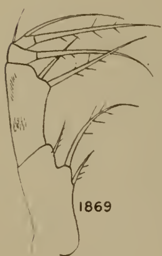
FIG. 1853.—Genital somite and receptaculum.
FIG. 1854.—Furcal rami. Norfolk.
FIG. 1855.—Antennule, segs. 16 and 17. Stanford Water.
FIG. 1856.—Antennule, segs. 16 and 17. Ormesby.
FIG. 1857.—Antennule, segs. 16 and 17. Windermere.
FIG. 1858.—Antennule, segs. 16 and 17. Friesland.
FIG. 1859.—Antennule, segs. 16 and 17. Lake Tiberias.
FIG. 1860.—Antennule, segs. 16 and 17. Ceylon.
FIG. 1861.—Antennule, segs. 16 and 17. Victoria Nyanza.
FIG. 1862.—Antennule, segs. 16 and 17. Hoveton, Norfolk.
FIG. 1863.—Antennule, segs. 16 and 17. Sarawak, Borneo. (*C. aspericornis*, Daday.)
FIG. 1864.—Antennule, segs. 16 and 17. S. America, Chaco. (*C. longisetus*, Thieb.)

Female.—Length ·88–1·13 mm.

Form of body variable, more slender in limnetic forms; greatest width of thorax about one-third total length. Genital somite long and narrow, scarcely expanded anteriorly, length about $1\frac{1}{2}$ times width. Receptaculum T-shaped, consisting of a long narrow posterior sac reaching nearly to end of somite, and a transverse anterior part, not recurved. Abdominal somites without posterior marginal serration. Furcal rami slightly divergent, $3–3\frac{1}{2}$ times as long as wide, and 80–94°/₀₀ of body length; inner margins smooth, except in forma *pilosa*, Kiefer, from Madagascar and S. Africa; lateral seta inserted a little beyond middle; inner apical seta more than twice as long as outer, and twice as long as ramus. Antennule of 17 segments, reaching generally to end of first free thoracic somite; last 2 segments with a broad hyaline membrane. Membrane of seg. 16 generally very finely serrated; that of seg. 17 more coarsely serrated, and with one or more conspicuous notches anteriorly. Antenna very slender. Maxilla with outer margin of seg. 2 (basis) conspicuously ribbed. Legs with rami 3-segmented; spine formula 2.3.3.3; coxa with a few long delicate hairs on outer margin; uniting lamella, except in leg 4, with straight edge. Leg 1, basis without inner seta; outer margin of exopod segs. 2 and 3 with fringe of hairs. Legs 2 and 3 alike; seg. 3 of endopod very slender, the setæ not reaching nearly to end of apical spine; outer margin of exopod segs. 2 and 3 with short spinules. Leg 4, uniting lamella with a pair of pointed processes, variable in size, and either long and slender, or short and blunt; endopod 3 generally about 3 times as long as wide; setæ scarcely reaching beyond end of segment; apical spines shorter than segment, the outer generally a little the longer, but occasionally shorter than inner spine; spines generally with lateral fringe of very delicate spinules, rarely with stout spinules. Leg 5, seg. 2 slender, with long apical seta, and long inner spine inserted near end, and nearly as long as apical

seta; inner spine commonly diverging from segment at a wide angle. Egg-sacs large, divergent.





FIGS. 1865–1871.—*Cyclops leuckarti.*

FIG. 1865.—Antennule, male, segs. 1–4.
FIG. 1866.—Antenna.
FIG. 1867.—Maxillule.
FIG. 1868.—Maxilla.
FIG. 1869.—Maxillipede.
FIG. 1870.—Leg 1.
FIG. 1871.—Leg 2.

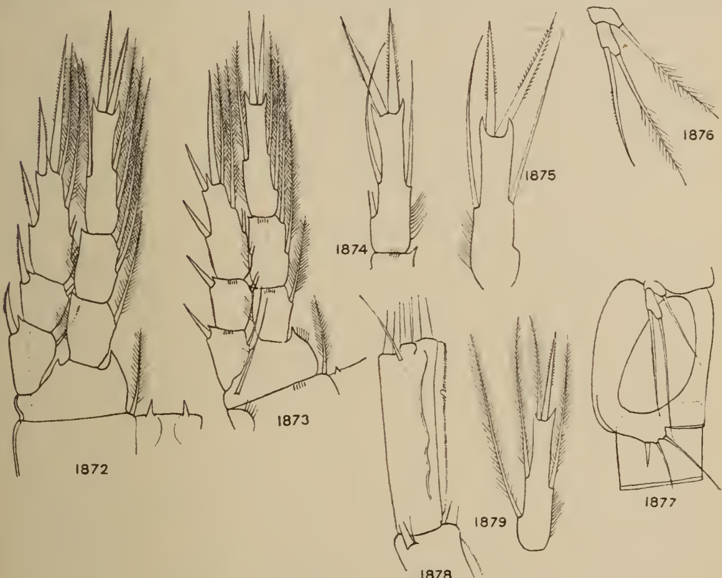
Colour greyish, sometimes with darker bands.

Male.—Length ·75–·9 mm.
Antennule with long æsthetes on segs. 1 and 4, and

smaller one on seg. 9. None seen on seg. 13. Leg 6 with stout inner spine and 2 slender setæ.

VARIATION.

As will be seen from the table of measurements, there may be considerable differences in populations



FIGS. 1872–1877.—*Cyclops leuckarti.*

FIG. 1872.—Leg 4, Ormesby.
FIG. 1873.—Leg 4, Lake Tiberias.
FIG. 1874.—Leg 4, endopod 3. Ceylon.
FIG. 1875.—Leg 4, endopod 3. Victoria Nyanza.
FIG. 1876.—Leg 5.
FIG. 1877.—Legs 5 and 6, male.

FIGS. 1878, 1879.—*Cyclops leuckarti bodanicola*, Kiefer.
FIG. 1878.—Antennule, seg. 17. FIG. 1879.—Leg 4, endopod 3.

from different British localities. For example, the Windermere form is exceedingly slender, and has the endopod of leg 4 more slender than usual, but the furcal setæ shorter. The form of the hyaline membrane of the antennule is by no means constant among individuals of the same population. I find the form

with a single large notch, which is regarded by Kiefer as typical, much rarer than membranes with a deep notch and a less deep one on either side of it. In the form from Windermere there can hardly be said to be any marked notch. I have compared specimens from Ceylon, Egypt, Palestine and East Africa with those from Britain, and find them fully within the range of normal variation. Kiefer has separated two subspecies, *C. l. bodanicola* from Lake Constance, and *C. l. æquatorialis* from equatorial Africa. The former is characterized by exceptional slenderness, reduced serration of the antennular membrane, and by conversion of the inner apical spine of leg 4 into a seta. The latter character alone seems to separate this form from that of the English lakes. I have examined specimens from Lake Constance (Figs. 1878, 1879), and give measurements. Although there seems to be no other distinguishing character, the transformation of this spine is so unusual that it justifies retaining Kiefer's name. *C. monardi*, Perret (Switzerland) does not differ in the smallest respect from the typical form.

Kiefer's *C. l. æquatorialis* is defined as having the rami shorter, and endopod of leg 4 broader than in typical form, and its distribution is given as equatorial Africa, India, and Sunda Islands. On the other hand, he admits that the typical form is also found in the Sunda Islands together with the subspecies, and also in other places within the range of the latter. I have examined specimens from Sarawak, Lahore, and Victoria Nyanza, and give measurements. While those from Sarawak and Ceylon have particularly short rami, the former only have also a relatively short endopod of leg 4, and I see no reason to distinguish either. The Sarawak form has a pitted cuticle, and corresponds to Daday's *C. aspericornis*. Lowndes (1930F) notes the variability of this species, and treats the form common in Abyssinia as typical. With regard to America the position is different. According to Marsh both the typical form, and a form regarded as a subspecies of it, *C. l. edax*,

C. leuckarti.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Outer % of inner spine.	Longest spine % of end. 3.
1. Norfolk, Ormesby Broad	1·05	315	81	3·36	63	85	281	395	171	3·05	121	98
2. ,, ,, .	·95	328	94	3·63	62	95	300	455	200	3·35	113	83
3. ,, ,, .	·88	306	89	3·12	60	85	286	440	194	3·3	114	90
4. ,, ,, ♂	·78	300	83	3·15	59	96	320	480	225	3·55	107	82
5. ,, Hoveton Broad	1·13	320	83	3·45	62	97	310	433	194	3·05	129	93
6. ,, ,, .	1·05	340	90	3·45	62	93	200	420	193	3·2	114	88
7. ,, Seamere . .	1·02	340	90	3·0	63	104	337	490	220	3·45	114	92
8. ,, Stanford Water.	·96	365	88	3·42	63	78	265	384	162	2·9	117	87
9. Windermere . .	1·05	285	88	3·75	63	95	269	295	206	4·06	86	66
10. ,, . . .	1·08	260	83	3·3	57	88	260	. .	185	3·0	94	78
11. ,, ♂ . .	·83	265	90	3·7	54	78	234	337	180	3·26	94	83
12. Loch Lomond . .	·875	320	93	3·6	59	104	355	535	240	3·3	100	74
13. Holland, Naardermeer .	·94	320	95	3·75	53	85	320	450	200	3·45	93	85
14. Lake Constance (*C. l. bodanicola*)	·86	374	93	2·87	62	93	337	520	158	3·5	78	70
15. Ditto	·82	270	92	3·85	62	83	305	. .	206	3·9	116	70
16. Palestine . . .	·98	356	103	3·8	61	92	345	462	214	3·05	100	83
17. ,, Lake Tiberias	·77	325	78	2·85	60	68	370	584	220	3·45	103	82
18. Seistan, Nasratabad .	1·26	300	87	3·75	62	87	282	395	183	3·05	103	76
19. India, Port Canning .	1·2	400	87	2·84	62	92	342	475	221	2·55	86	94
20. ,, Lahore . .	1·15	355	100	3·6	61	83	305	435	190	3·15	105	83
21. ,, Calcutta . .	1·13	335	88	3·55	65	79	310	425	186	3·05	108	85
22. Rangoon . . .	·8	375	82	2·73	62	81	331	550	226	2·54	97	88
23. Ceylon . . .	·97	330	72	2·75	61	72	320	450	195	3·2	100	77
24. ,, . . .	1·05	332	81	2·8	59	76	. .	445	190	3·15	105	69
25. Victoria Nyanza . .	1·18	305	82	3·35	58	78	350	. .	210	3·3	117	75
26. Sarawak . . .	·97	360	72	2·55	57	73	370	600	235	2·86	103	93
27. *C. longisetus* (S. America)	1·44	387	100	3·4	60	90	347	430	252	2·22	92	84

Forbes, occur in North America, the latter mainly characterized by having the inner margins of the rami hairy. In S. America the typical form is not known to occur, but it is represented by two closely allied species, *C. longisetus*, Thieb., and *C. annulatus*, Wierz. I have seen specimens of the former, and find them quite distinct, though closely resembling *C. leuckarti* in the form of the antennular membrane. This species differs from *C. leuckarti* in having an inner seta on the basis of leg 1. Van Douwe records *C. leuckarti* from S. America, and Marsh from Honduras, but it seems probable that in both cases one of these allied species was in question.

In these circumstances I regard this species as cosmopolitan (with the possible exception of S. America).

Distribution in Britain.

Common throughout central and southern England, but rarer in the north and apparently confined to lakes of the "more evolved" type. For example, in Lake District, found in Derwentwater, but not in lakes such as Crummock or Wastwater. In Scotland only in Lochs Achray (Scott), Lomond (Scott, R. G.), Lubnaig (D. J. S.), Lochmaben (Brady).

Ireland: Mallow, co. Cork (Brady); L. Derg (Southern and Gardiner).

Not yet recorded from Wales.

Distribution Abroad.

Europe: General.

Asia: Palestine (R. G.); Mesopotamia (R. G.); Baikal (Jaschnov); Seistan (R. G.); China (Daday); Japan (Kokubo); India, Lahore, etc. (R. G.); Ceylon (Apstein, Daday, R. G.); Sumatra (Richard, Sars); Borneo (R. G.); Tonkin (Richard); Celebes (Stingelin); Java (Daday, R. G.).

Africa: Algeria (Roy and Gauthier); Egypt (Daday, Ekman, etc.); Madagascar (Kiefer, R. G.); Abyssinia

(Lowndes); Zanzibar (Poppe and Mrázek); Central African Lakes, Kivu, Lahondo, Albert, Nyassa, Victoria, Albert Edward, Tanganyika (Daday, Sars); Camerun (Kiefer); West Africa, Rufisque (Richard); S. W. Africa (Van Douwe); Northern Nigeria (Brady); Cape (Sars).

America: North (Marsh, etc.); South—(?) Brazil (Van Douwe); Honduras (Marsh).

Australian region: New South Wales (Henry, Sars); New Zealand (Brady); Hawaii (Sars); New Hebrides (Lowndes).

Bionomics.

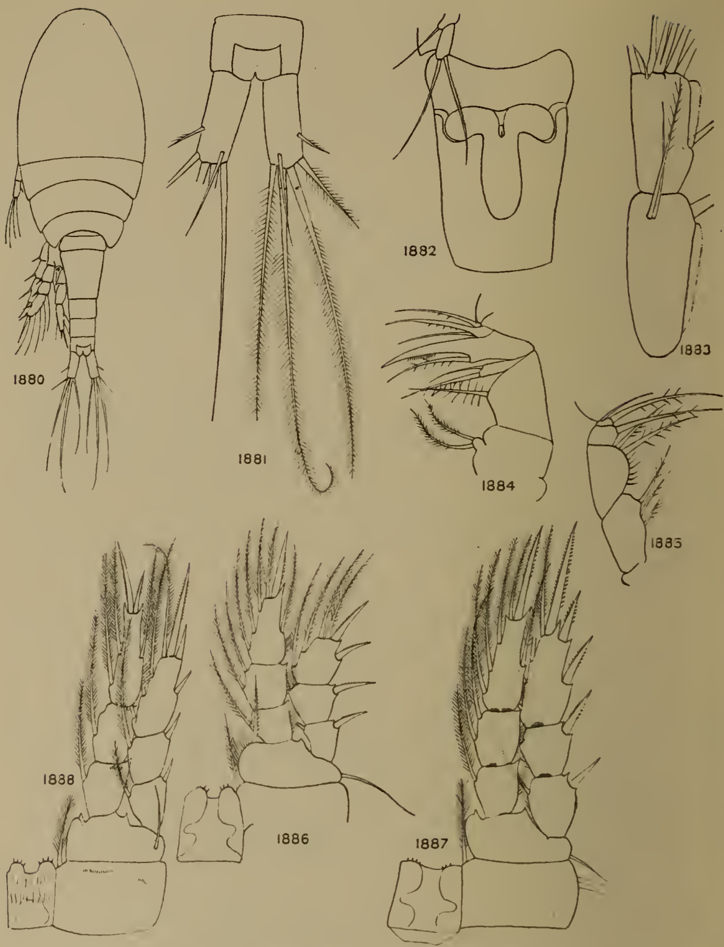
Found both in small pools and also in lake plankton. In Epping Forest a summer form, occurring from February to October (D. J. S.). Wolf (1905) found it in pools from March to October, with maxima in April and May; but in Lake Constance and other lakes, only in autumn.

Cyclops hyalinus, Rehberg.

(Figs. 1880–1896.)

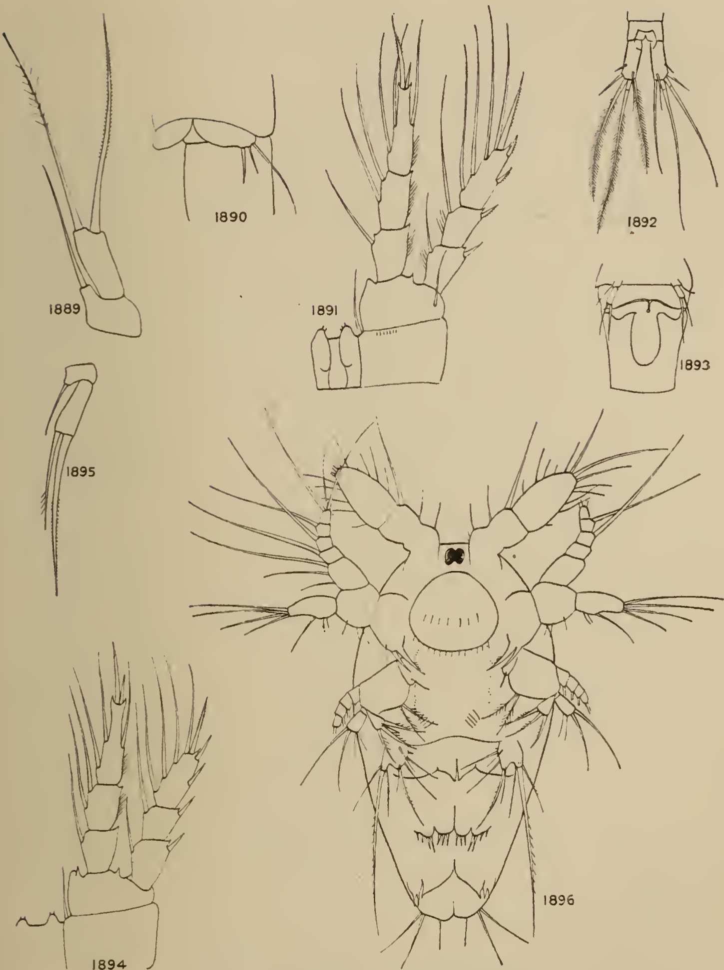
1880. *C. hyalinus*, Rehberg, Abh. Ver. Bremen, VI, p. 542, figs.
1891. ,, Richard, Ann. Sci. Nat. XII, p. 232, figs.
1892. *C. scourfieldi*, var., Brady, Trans. N. H. Soc. Northd. XI, p. 76, pl. vi.
1892. *C. oithonoides* var. *hyalina*, Schmeil, Bibl. Zool. XI, p. 68, figs.
1901. *C. hyalinus*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 40, figs.
1914. *Mesocyclops crassus*, Sars, Crust. Norway, VI, p. 61, figs.
1929. *M. hyalinus*, Kiefer, Tierreich, Lief LIII, p. 83.
1929. *M. decipiens*, Kiefer, Zool. Anz. LXXX, p. 316, fig.

Whether this is actually the species described by Rehberg is a little uncertain. Sars claimed that Rehberg was dealing with *C. oithonoides*, and that the name *C. crassus*, Fischer, should be applied to the species here described. It must be admitted that Rehberg's description, apart from the single positive statement as to the length of the antennule, provides no satisfactory means of separation from *C. oithonoides;* but it has been accepted by Schmeil and most other authors, and Schmeil has clothed Rehberg's name with an adequate description. For the use in its place of Fischer's name



FIGS. 1880–1888.—*Cyclops hyalinus.*

FIG. 1880.—Female, dorsal. Norfolk.
FIG. 1881.—Furcal rami. Oxford.
FIG. 1882.—Genital somite and receptaculum. Oxford.
FIG. 1883.—Antennule, female, segs. 16, 17.
FIG. 1884.—Maxilla.
FIG. 1885.—Maxillipede.
FIG. 1886.—Leg 1.
FIG. 1887.—Leg 2.
FIG. 1888.—Leg 4. Norfolk.



Figs. 1889–1896.—*Cyclops hyalinus.*

Fig. 1889.—Leg 5. Norfolk.
Fig. 1890.—Leg 6, male.
Fig. 1891.—Leg 4. Nile at Shabluka.
Fig. 1892.—Furcal rami. Ceylon.
Fig. 1893.—Receptaculum. Lahore.
Fig. 1894.—Leg 4. Lahore.
Fig. 1895.—Leg 5. Lahore.
Fig. 1896.—Nauplius, stage VI.

there is no reason. The fact that four different interpretations* have been placed upon Fischer's species shows that it is unrecognizable.

Female.—Length ·8–·10 mm.

Body rather stout and compact, the abdomen not much more than half length of thorax; greatest width of thorax about half its length. Genital somite longer than wide; receptaculum hammer-shaped, the lateral anterior limbs not recurved. Furcal rami rather divergent, not more than $2\frac{1}{2}$ times as long as wide; lateral seta inserted a little beyond middle; inner apical seta not much shorter than seta 2, and about 3 times as long as outer seta; dorsal seta about twice as long as ramus. Antennule reaching to end of first free thoracic somite; last 3 segments short; segs. 16 and 17 with broad hyaline membrane, very finely serrated at edge. Maxilla short and stout, not ribbed. Legs with rami 3-segmented, spine formula 2.3.3.3; uniting lamella of legs 2–4 with small marginal denticles; in leg 4 these are borne on rounded prominences with a deep groove between. Leg 1 basis with long inner seta; leg 4, endopod 3 about $2\frac{1}{2}$ times as long as wide; inner apical spine about twice as long as outer, and usually a little shorter than the segment. Leg 5, seg. 2 about $2\frac{1}{2}$ times as long as wide, with inner spine and apical seta of about the same length; inner spine inserted either quite apically or on a subapical notch, generally parallel to seta. Egg-sacs apposed to abdomen, with few eggs.

Colour: Yellowish or brownish yellow; legs brown, the spines of exopods purplish brown; some blue colour at base and ends of rami.

Male.—Length ·6 mm.

Antennule apparently without æsthetes on segs. 1 and 13; a very minute æsthete on segs. 4 and 9. I have only been able to examine satisfactorily a few

* *C. viridis* by Schmeil; *C. dybowskii* by Lilljeborg; *C. hyalinus* by Sars; *C. leuckarti* by Lande.

C. hyalinus.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Inner % of outer spine.	Inner spine % of end. 3.
1. Sutton, Norfolk . .	·8	337	69	2·25	61	64	243	300	200	2·34	215	100
2. ,, ,, . .	·78	360	70	2·57	58	71	256	..	205	3·52	200	77
3. ,, ,, ♂ .	·61	277	59	2·18	58	49	205	261	180	3·3	210	77
4. ,, ,, ♂ .	·57	305	63	2·2	53	54	225	299	200	3·6	200	76
5. Oxford . . .	·875	310	68	2·62	62	69	240	275	205	2·70	176	..
6. France, Vichy . .	·88	295	62	2·42	59	62	210	237	170	3·0	205	73
7. India, Lahore . .	1·03	..	80	3·0	66	67	222	263	147	2·65	160	80
8. ,, ,, ♂ .	·67	280	89	3·5	62	52	260	..	210	3·0	180	76
9. ,, Calcutta (1) .	·9	300	69	3·0	68	55	235	282	172	3·45	262	89
10. ,, ,, (2) .	·87	286	60	2·66	63	56	240	252	175	3·36	250	82
11. Ceylon, Kandy. .	·75	305	67	2·8	68	60	253	335	194	3·1	270	104
12. R. Nile, Shabluka .	·95	315	63	2·3	60	73	230	295	146	3·4	212	87
13. ,, . . .	·91	265	66	2·62	62	55	221	..	176	3·5	257	96

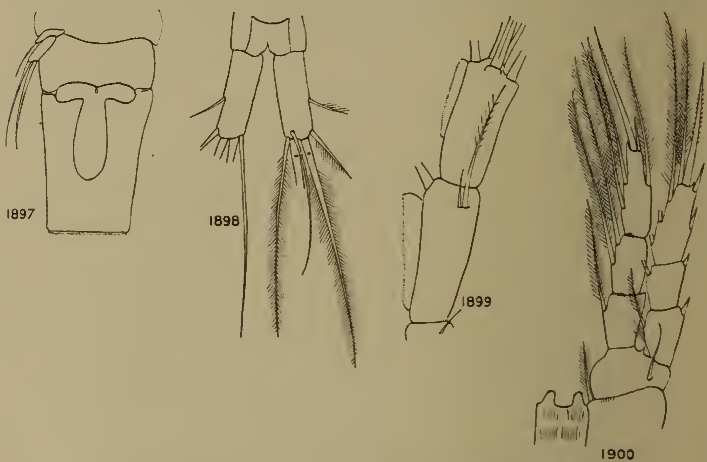
C. oithonoides.

Friesland . . .	·75	..	75	2·85	50	62	207	288	185	2·82	410	156

specimens from Norfolk, and cannot, therefore, say if this loss of æsthetes is generally true. Leg 6 with very long outer seta ; middle seta shorter than inner spine.

Variation.

My material from European localities is very limited, but sufficient to show that there is considerable variation in all the characters regarded as specific. For example,



Figs. 1897–1900.—*Cyclops oithonoides* (Friesland).
Fig. 1897.—Receptaculum. Fig. 1899.—Antennule, segs. 16, 17.
Fig. 1898.—Furcal rami. Fig. 1900.—Leg 4.

two specimens from the same collection have leg 4, endopod 3 differing greatly in slenderness and in lengths of spines (see table, p. 299, Nos. 1 and 2). I have had for comparison specimens from Ceylon, India, Egypt and the Sudan. None of these agree completely with the European form, neither do those from India and Ceylon agree exactly with those from Egypt and the Sudan. None the less I feel no doubt that all represent one species, of wide range and local and individual variability. The specimens from the Nile are, in some ways, intermediate between *C. hyalinus* and *C. oithonoides*.* They

* Figures of *C. oithonoides* from Friesland are given here for comparison (Figs. 1897–1900).

differ from *C. emini*, which is a common species of the upper Nile, in having spinules on the uniting lamella of leg 4 and a shorter dorsal furcal seta. No less than 27 species of "*Thermocyclops*" have now been described, several of which differ less from typical *C. hyalinus* than some of these Indian and African specimens do, and it seems there need be no end to the number that may be described in future if reliance is placed on minute differences in lengths of segments, spines and setæ. It is desirable that the range of variation of the European form should first be established, and that these new species should be revised in the light of the results.

Distribution in Britain.

Apparently confined to the east and south-east.
Cambridge : Wicken Fen (A. G. L.).
Norfolk : Common throughout the Broads (R. G.).
Suffolk (D. J. S.).
Essex : Epping, etc. (D. J. S.).
Hampshire : Beaulieu (R. G.).

Distribution Abroad.

Europe : Probably generally distributed, from Norway southwards.

Asia : Manchuria (Rylov) ; Tongking (Richard) ; Tiflis (Richard) ; India, Ceylon (R. G.) ; Japan (Harada).

Africa : Egypt, Sudan (R. G.) ; Barka (Brehm) ; Lybia (Colosi) ; Camerun (Kiefer) ; Central Africa (Van Douwe) ; Canaries (Richard). (Allied or identical (?) forms in South and East Africa.)

Australian Region : New Hebrides (A. G. L.).

America : Central (Kiefer).

Bionomics.

Found only in summer, either in ditches with clear water and rich vegetation, or in plankton in the Norfolk Broads.

Cyclops dybowskii, Lande.

(Figs. 1901–1915.)

1890. *C. dybowskii*, Lande, Pam. Fizyjogr. X, p. 363, figs.
1892. ,, Schmeil, Bibl. Zool. XI, p. 72, figs.
1901. *C. crassus*, Lilljeborg, Svenska Akad. Handl. XXXV, p. 38, figs.
1907. *C. dybowskii*, Van Breemen, Tijdschr. Ned. Ver. (2), X, p. 333, figs.
1914. *Mesocyclops dybowskii*, Sars, Crust. Norway, VI, p. 62, figs.
1929. ,, ,, Kiefer, Tierreich, Lief. LIII, p. 84.

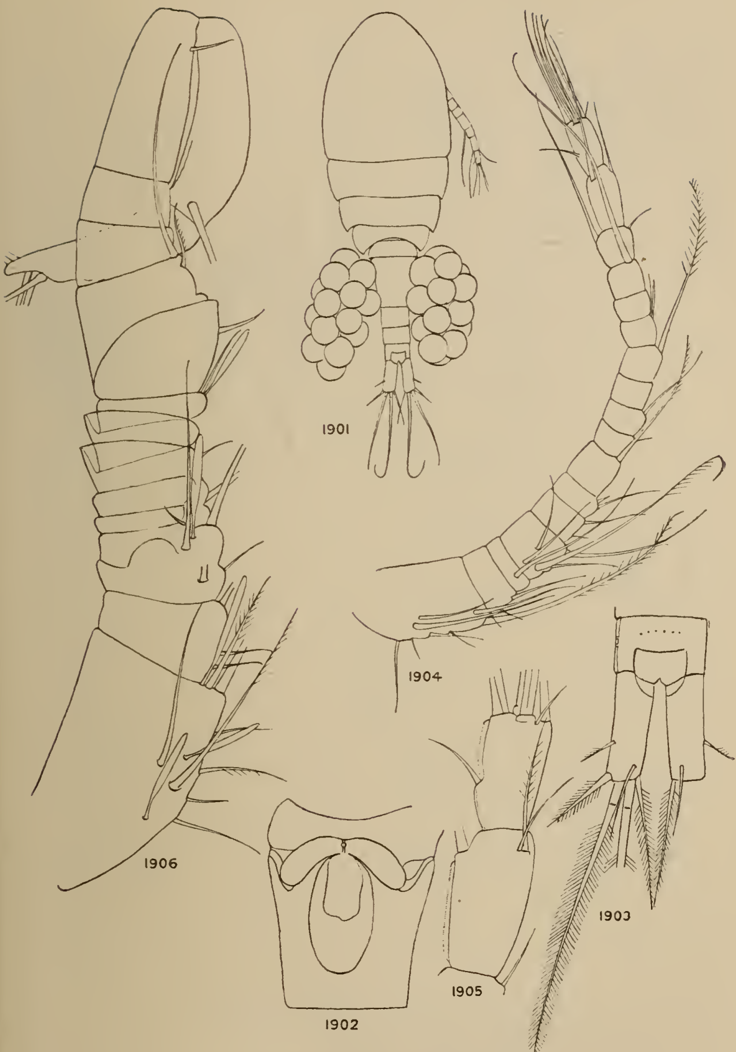
Female.—Length ·67–·85 mm.

General form as in *C. hyalinus*; genital somite rather short and stout, length not much exceeding width; receptaculum with anterior part markedly recurved. Furcal rami less than 3 times as long as wide, generally about $2\frac{1}{2}$ times; lateral seta inserted beyond middle (57–64%); inner apical seta less than twice as long as outer; dorsal seta reaching about to end of outer seta. Antennule reaching to near end of 2nd free thoracic somite, of 17 segments, the last segments short; segs. 16 and 17 with a very narrow hyaline membrane, often almost invisible, and confined, in seg. 17, to distal half; sensory seta of seg. 16 more than half as long as seg. 17. Uniting lamella of legs 1–4 with small denticles on either side, but without pronounced lateral projections. Leg 1 with long seta on coxa. Leg 4, endopod 3 about 3 times as long as wide; outer apical spine a little longer than inner, and about 70% of length of seg. 3. Leg 5, seg. 2 rather stout; inner apical spine inserted nearly at apex, a little longer than apical seta, and about 3 times as long as segment. Egg-sacs rather divergent.

Colour: Generally brownish, the rami and legs darker, and commonly tinged with violet.

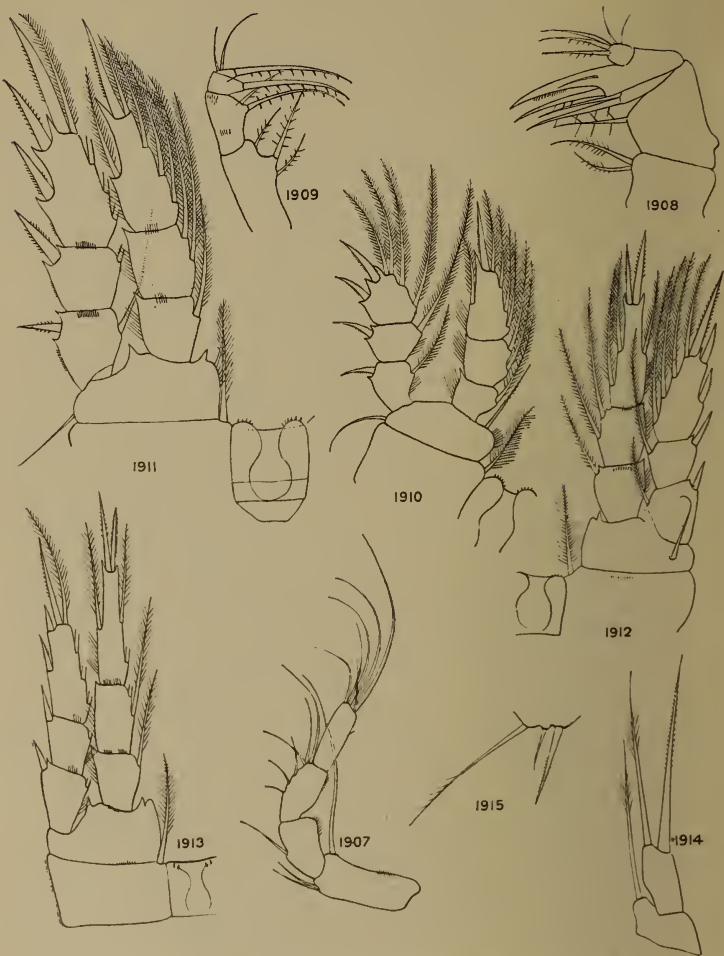
Male.—Length ·65 mm.

Antennule with long æsthetes, of normal number, on segs. 1, 4 and 9; none seen on seg. 13. Leg 6, middle seta much shorter than inner spine; outer seta very long.



FIGS. 1901–1906.—*Cyclops dybowskii.*

FIG. 1901.—Female, dorsal.
FIG. 1902.—Genital somite and receptaculum.
FIG. 1903.—Furcal rami, dorsal.
FIG. 1904.—Antennule, female.
FIG. 1905.—Antennule, segs. 16, 17.
FIG. 1906.—Antennule, male.



FIGS. 1907–1915.—*Cyclops dybowskii.*

FIG. 1907.—Antenna.
FIG. 1908.—Maxilla.
FIG. 1909.—Maxillipede.
FIG. 1910.—Leg 1.
FIG. 1911.—Leg 2.
FIG. 1912.—Leg 4.
FIG. 1913.—Leg 4. Palestine.
FIG. 1914.—Leg 5.
FIG. 1915.—Leg 6, male.

C. dybowskii.

	Body.		Furcal rami.			Furcal setæ.				Leg 4. Endopod 3.		
	Length.	Width.	Length.	L. : w.	Lateral seta.	1.	2.	3.	4.	L. : w.	Outer % of inner spine.	Outer spine % of seg. 3.
1. Ingham, Norfolk .	·85	350	76	2·32	57	57	180	260	95	3·15	116	72
2. ,, ,, . .	·91	340	78	2·8	64	55	215	264	98	2·9	112	66
3. ,, ,, ♂ .	·65	317	77	2·5	68	46	215	323	116	2·8	109	74
4. Barton, Norfolk . .	·88	350	80	2·67	67	57	205	250	105	3·1	120	73
5. Palestine, Tiberias .	·67	370	97	3·5	66	60	225	328	104	3·0	125	90
6. Holland, Friesland .	·86	325	68	2·7	66	64	233	. .	203	3·16	121	82

Variation.

There does not appear, from the limited material available to me, to be much variation. I have specimens from near Lake Tiberias which are typical in all respects, except for having the rami rather longer and more slender. Very closely allied, and perhaps better to be regarded as subspecies, are *C. schmeilii*, Poppe and Mrázek, and *C. rylovi*, Smirnov. The former seems to differ only in the longer rami, and longer inner spine on leg 5. The latter, from the Caucasus, differs in having the dorsal furcal seta shorter, outer apical spine of leg 4 shorter, and inner spine of leg 5 longer.

Distribution in Britain.

Scotland: Loch Lomond (Scott); Great Cumbrae (D. J. S.).
Yorkshire: Bradford (R. G.).
Cumberland: Derwentwater and Windermere (R. G.); Grasmere, Esthwaite (D. J. S.).
Norfolk: Eight localities (R. G.).
Hampshire: Beaulieu (R. G.).
Essex: Epping, etc. (D. J. S.).
Kent: Sandwich (D. J. S.).
Somerset: Minehead (D. J. S.).
Sussex: Pevensey (D. J. S.).
Anglesey: Isle of Man (D. J. S.).
Wiltshire: Tisbury (D. J. S.).

Distribution Abroad.

Europe: Widely distributed.
Asia: Turkestan (Van Douwe); Palestine and Mesopotamia (R. G.).
Africa: Algeria (Roy and Gauthier); Egypt, (Chappuis, Graeter, R. G.); Ethiopia (Daday); E. Africa (Daday, Grochmalicki).

Bionomics.

A rare species in this country, found only in summer, and generally confined to small ponds where the water is not contaminated.

Suborder **PŒCILOSTOMA**, Sars.

1917. Sars, Crust. Norway, VI, p. 142.

Copepods of semi-parasitic habits. Antennules of male not prehensile; antenna without exopod, generally more or less prehensile; upper lip not transformed into a tube; mandible without exopod or cutting blade, commonly produced into a slender process; maxillule vestigial; maxilla not prehensile; maxillipede prehensile in male, reduced and sometimes absent in female; legs generally well developed, with rami 3- or 2-segmented; leg 5 unsegmented or of 2 segments.

Nauplius, in such genera as are known, hatched with normal appendages functional for feeding.

Sars follows Thorell in assuming that the mandibles are absent, the first mouth appendage being designated the maxilla, the small lamellar appendage attached just outside it being the palp. The fact that the "palp" can, in some cases (e.g. *Thersitina*, *Tucca*, *Tæniacanthus*), be shown not to be a part of the appendage to which it has the appearance of being attached, seems sufficient to prove that it is itself the maxillule, and the appendage in front of it the mandible.* In some Ascomyzontidæ, where the mandible is admittedly present, the maxillule is almost as much reduced as in the Pœcilostoma. In some genera (*Mytilicola*, *Trochicola*) the mandible itself has been lost (Monod and Dollfus, 1932, p. 161), but the same small vestige of the maxillule persists.

Sars includes seven families in this group, but the position of one of these, the Eunicicolidæ, is doubtful. It should probably be referred to a position near *Nicothoe*. Only one family, the Ergasilidæ, is represented in fresh water.

* See Wilson, 1911, p. 282; Gurney, 1927, p. 464.

ERGASILIDÆ.

1833. *Ergasilina* (part), Burmeister, Acta Acad. Caes. Leop. XVII, p. 318.
1859. *Ergasilidæ*, Thorell, Svenska Akad. Handl. III, p. 14.
1911. ,, Wilson, Proc. U.S. Nat. Mus. XXXIX, p. 310.
1918. ,, Sars, Crust. Norway, VI, p. 197.

Body cyclopoid in shape, either throughout life, or in male and early adult stage; somite of leg 1 free or fused with cephalothorax; th. som. 5 much reduced, or fused with genital somite. Antennule short, of few segments, alike in both sexes; antenna with strong prehensile claw, stronger in female; mandible with brush-like terminal claw; maxillipedes absent in female; legs 1–4 well developed; leg 5 reduced, unsegmented. Genital aperture dorsal; two egg-sacs; receptaculum dorsal above intestine (Wilson). Larvæ free-swimming till adult stage reached; males free throughout life.

Development.

The nauplius stages of *Ergasilus* have been described by Wilson (1911), and the whole larval history is known for *Thersitina*. Development follows precisely the same course as in *Cyclops*, but the exact number of nauplius stages is a little uncertain. Wilson alludes to five moults, but describes only three stages. In *Thersitina* I have seen four stages, but a fifth stage must be assumed between the oldest seen and the copepodid. There are five copepodid stages, as in *Cyclops*.

Nauplius.

Thersitina gasterostei.

(Figs. 1916–1918.)

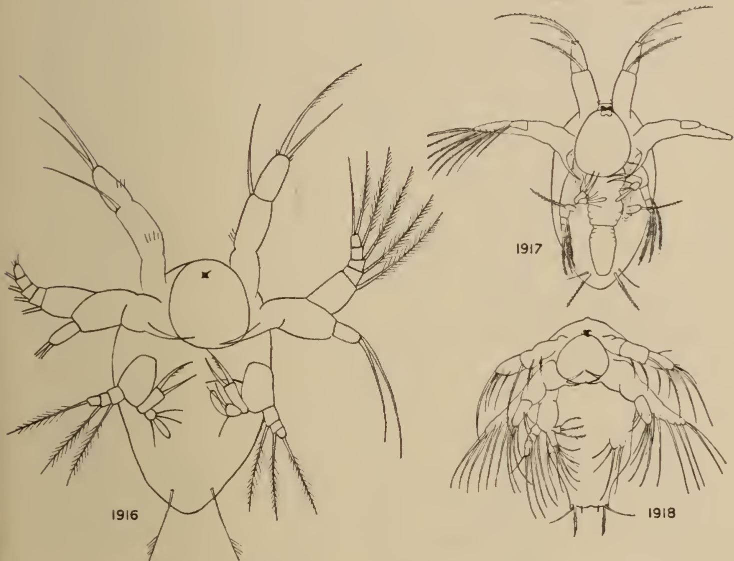
Stage I: Length ·1 mm.

Body pear-shaped. Labrum large, not fringed with hairs; one pair of furcal setæ. Antennule of 3 faintly marked segments, with 2 unequal apical setæ and one seta on seg. 2. Antenna with exopod of 5 segments, with 6 setæ; coxa with hooked masticatory process.

Mandible with exopod of 3 segments with 3 setæ; endopod of 2 segments, seg. 1 with 2 inner spines, seg. 2 with 3 setæ and a spatulate æsthete or modified seta.

Stage II differs only in having 2 pairs of furcal setæ.

Stage III has a rudiment of the maxillule in the form of a papilla with one seta.



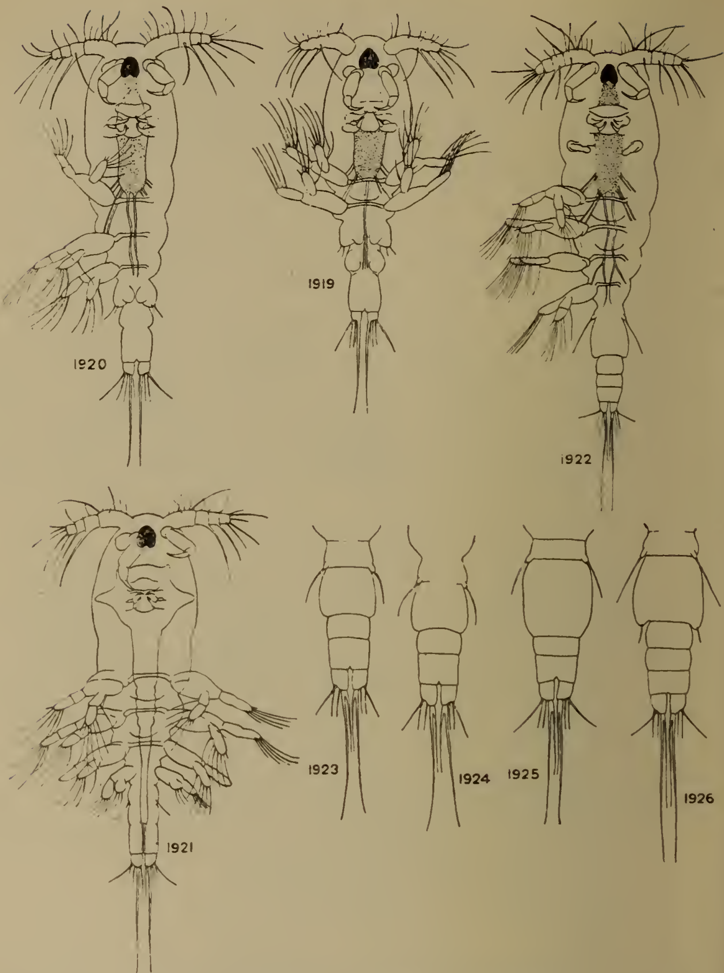
FIGS. 1916–1918.—*Thersitina gasterostei.*

NAUPLII.

FIG. 1916.—Nauplius, stage I.
FIG. 1917.—Nauplius, stage III.
FIG. 1918.—Nauplius, stage IV.

Stage IV has 2 pairs of furcal setæ and 2 pairs of small spines. The mandible has lost the æsthete of the endopod and has 3 spines in the masticatory fork. The maxillule is a bilobed plate. No older stage has been seen.

Wilson figures the last nauplius of *Ergasilus*, which is hardly distinguishable from that of *Cyclops*. He shows, however, the rudiment of the maxillule at the base of the mandible, and interprets the appendage which



FIGS. 1919–1926.—*Thersitina gasterostei.*

COPEPODID STAGES.

FIG. 1919.—Copepodid, stage I.
FIG. 1920.—Copepodid, stage II.
FIG. 1921.—Copepodid, stage III.
FIG. 1922.—Copepodid, stage V, male.
FIG. 1923.—Abdomen, copepodid IV, female.
FIG. 1924.—Abdomen, copepodid IV, male.
FIG. 1925.—Abdomen, copepodid V, female.
FIG. 1926.—Abdomen, copepodid V, male.

in *Cyclops* becomes the maxillule as the maxilla. There are also rudiments of the maxillipedes as well as those of 2 pairs of legs.

Copepodid Stages.

(Figs. 1919–1926.)

The five copepodid stages are similar to those of *Cyclops*. At stage IV there is distinction of sex, the male having a rudiment of the maxillipede, but being otherwise indistinguishable. In the female no trace of the maxillipede appears at any stage—a fact which may be commended to the attention of firm believers in recapitulation. In stage I the furcal rami are very short, with a long inner apical seta and 4 short, slender setæ. In stages II–IV the two inner setæ are fused at their base and the inner one is the shorter of the two. Comparison with *Cyclops* shows that the dorsal seta is never developed, and that the innermost seta, which is the longest in stage I, disappears in the adult. In the free-swimming adult female the somites of legs 1 and 2 are quite distinct. As soon as the female enters the gill chamber of the fish she loses either the power or the inclination for movement, even before the swelling of the thorax makes movement impossible.

ERGASILUS, Nordmann.

1832. V. Nordmann, Mik. Beit. Wirb. Thiere, Berlin, p. 7.
1911. Wilson, Proc. U.S. Mus. XXXIX, p. 327.
1918. Sars, Crust. Norway, VI, p. 198.

Cephalothorax united with somite of leg 1 in adult female and more or less inflated; body in male and young female somewhat flattened, with segmentation complete; somite of leg 5 sometimes indistinguishable; furcal rami with very long inner seta; antennule of 6 segments,* with numerous setæ; antenna 4-segmented, with strong terminal claw; legs 1–4 with both rami

* *E. lagunaris*, Grandori (1926), has only 5 segments in the antenna of the male. The species is founded on a single male taken in the lagoon of Venice.

3-segmented except leg 4, in which the exopod is of 2 segments. Leg 5 unsegmented, with 2 setæ.

Females parasitic on gill-filaments of fishes.

Type.—*E. sieboldi*, Nordmann.

Wilson included 16 species in his revision of the genus in 1911, and the number has since been doubled. Of these species, most of which live on fresh-water fish, 16 are recorded from North America; the remainder are scattered over all regions of the world except Australia.

Ergasilus sieboldi, Nordmann.

(Figs. 1927–1935.)

1832. *E. sieboldi*, *E. gibbus*, *E. trisetaceus*, v. Nordmann, Mikrograph. Beitr. Heft 2, p. 15, figs.
1863. ,, Kröyer, Naturh. Tidsk. (3), II, p. 311, figs.
1875. ,, Claus, Zeits. wiss. Zool. XXV, p. 339, figs.
1904. ,, *E. trisetaceus*, *E. gibbus*, Gadd, Acta Soc. Faun. Fenn. XXVI, No. 8, p. 4, figs.
1910. ,, Freidenfelt, Lunds Univ. Arsskr. N.F. VI, Afd. 2, No. 2, 12 pp.
1910. ,, Wegener, Schr. phys. ökon. Ges. Königs., 1909, Jg. 50, p. 65 (sep.).
1911. ,, Wilson, Proc. U.S. Nat. Mus. XXXIX, p. 338.
1912. *E. surbecki*, Baumann, Zool. Anz. XL, p. 53, figs.
1915. *E. hoferi*, Borodin, Zeits. Fischerei, XVII, p. 201, figs.
1926. *E. surbecki*, Lehmann, Schr. phys. ökon. Ges. Konigs. LXV, Heft 1, p. 61.
1926. *E. baikalensis*, Messjatzeff, Arch. f. Naturg. XCII, Heft 4, p. 122, figs.
1929. *E. sieboldi*, Neuhaus, Zeits. Fischerei, XXVII, p. 341.
1931. ,, Markewitsch, Zool. Anz. XCVI, p. 126, figs.

Adult female.—Length 1·0–2 mm.

Cephalothorax more or less dilated, much wider than succeeding somites; head region marked off ventrally by a strong chitinous bar behind antennæ; nuchal organ faintly marked or invisible; somite of leg 1 clearly marked off from cephalothorax. Thoracic somites separated by deep lateral incisions; th. som. 5 very narrow, but distinct. Genital somite much wider than long, and longer than succeeding 3 somites; genital openings dorsal. Furcal rami about twice as long as wide, without lateral seta; apex with 5 setæ. In dorsal view 3 are seen, a small dorsal seta situated near outer angle, a very long inner seta, stout at base and

not jointed, and an outer seta nearly twice as long as ramus. Two slender setæ are situated on ventral side at apex, and are visible from above only with difficulty. Antennule of 6 short segments, with setæ as follows (Markewitsch, 1932):

	1	2	3	4	5	6
Setæ . .	3 .	11 .	5 .	4 .	2 .	7

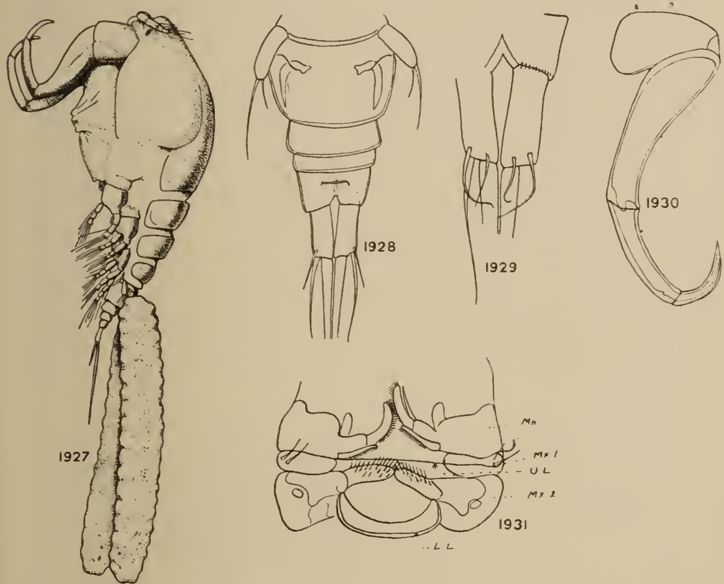
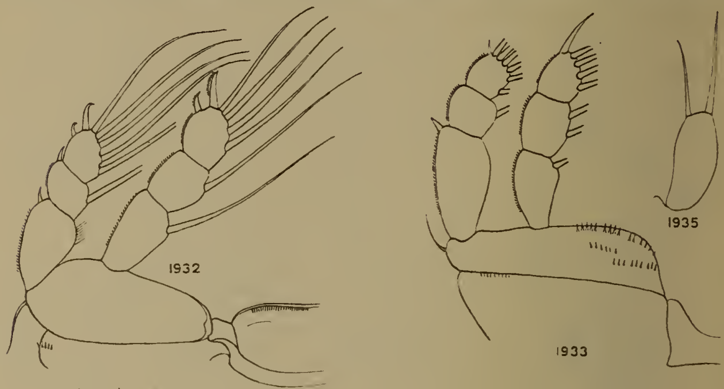


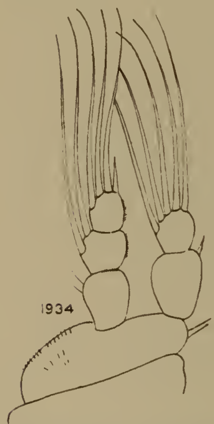
FIG. 1927–1931.—*Ergasilus sieboldi.*

FIG. 1927.—Adult female, lateral. After Markewitsch.
FIG. 1928.—Abdomen, dorsal.
FIG. 1929.—Furcal rami, ventral.
FIG. 1930.—Antenna.
FIG. 1931.—Mouth-parts. *Mn.*, mandible; *Mx.* 1, maxillule; *Mx.* 2, maxilla; *U.L.*, upper lip; *L.L.*, lower lip.

Antennæ of 4 segments, the relative lengths of segments as follows: 42.71.42.30. Mouth region in form of a compact cone, of which the side is formed by the large base of the maxilla, while the upper lip hangs over the mandible, and the lower lip closes the cone behind. Mandible with stout jointed terminal spine, with brush-like edge, and a small adjacent smooth spine; an

additional combed spine, which Wilson regards as the palp, is inserted on posterior side, the comb directed backwards. Maxillule a small vestige, bearing 2 small setæ. Maxilla with large basal part bearing a terminal





Figs. 1932–1935.—*Ergasilus sieboldi.*

Fig. 1932.—Leg 1.
Fig. 1933.—Leg 2.
Fig. 1934.—Leg 4.
Fig. 1935.—Leg 5.

movable process covered with short spines. Maxillipede absent. Legs with coxa and basis very broad, without inner setæ. Rami of 3 segments except in leg 4, in which exopod is 2-segmented ; outer spines of exopods very small, and absent from seg. 2 of legs 2 and 3 ; exopod 1 without inner seta* ; endopod 2 of legs

* In *E. baicalensis* Messjatzeff found a seta on exopod 1 of leg 1, and in *E. hoferi* Borodin describes 2 setæ on endopod 2 and 5 on endopod 3 (leg 1). Markewitsch considers such differences insufficient to characterize species, and possibly due to individual variation.

2–4 with 2 setæ. Leg 5 unsegmented, with 2 small setæ. Egg-sacs very large. Body colourless, except for blue pigment surrounding intestine.

Male.—Length 1·1 mm. (Sars).

Body very slender, but resembling female before fixation. Antennules as in female. Antennæ of same form as in female, but much smaller. Maxillipedes present, of 5 segments, forming a slender clasping organ.

The four species of *Ergasilus* described from European fresh-water fishes have been separated from *E. sieboldi* mainly on the number and lengths of the setæ of the furcal rami. Neuhaus (1929) and Markewitsch (1931) have dealt with abundant material, and both conclude that the apparent differences are founded on error. Two of the furcal setæ are very small, and on the ventral side, and one or more of them have been overlooked. Differences in shape of body are unimportant, as shape varies with maturity and ripening of ovaries. There is therefore only one widely distributed species.

Distribution and Bionomics.

While *E. nanus* is recorded from the gills of Grey Mullet at Aberdeen and Falmouth, *E. sieboldi* has not yet been seen in Britain. A description is included here, as it is most probable that it actually does occur, or that it may in future be introduced. It is found abundantly throughout Europe, and as far east as Lake Baical, and may become a serious pest. Several instances are known of great mortality in fish, particularly Tench, caused by inordinate increase of the parasite. Neuhaus, for instance, mentions 3000 specimens on a single Tench of 25 cm. It is found only on the gills, and always, according to Neuhaus, oriented with the head towards the base of the gill. This position is determined by the direction of the current, for, if placed in a reverse current, the animal will change its position to meet it. Spandl (1925) enumerates 15 species of fish as hosts, but it is most common on

Tench, Bream and Pike.* Egg-sacs appear in April. Neuhaus suggests that the best way to get rid of the parasite from a fish-pond is to remove and clean the fish in winter when the *Ergasilus* is not breeding. He found no free-swimming larvæ in plankton, and attempts to infect fish in boxes were successful only when the boxes were close to shore.

Wilson (1916) has made most interesting observations on the economic importance of *Ergasilus* in relation to fresh-water mussel culture. The same fish which are most commonly the hosts of *Ergasilus* are also the best hosts for the glochidia-larvæ of the mussels, but occupation of the gills by the copepods acts as an almost complete check to infection by glochidia. Control of the copepods is therefore most desirable. As the presence of glochidia also inhibits infection by copepods, it may be possible, by artificial infection with glochidia at seasons when the copepods are at their minimum, to deprive them largely of lodgment, and so to decrease their numbers.

THERSITINA, Norman.

1861. *Thersites*, Pagenstecher, Arch. Naturg. XXVII, p. 118.
1905. *Thersitina*, Norman, Mus. Normanianum, III, p. 41.
1911. ,, Wilson, Proc. U.S. Nat. Mus. XXXIX, p. 347.

Cephalothorax, including somites of legs 1 and 2, very much swollen in mature female, and almost spherical. Antennule of 5 segments; antenna prehensile, short. Mandible with toothed blade and without movable process. Maxillule with 3 setæ.

Type.—*T. gasterostei*, Pagenstecher.

The single species of this genus has been included by some authors in *Ergasilus*, but the differences in structure, and also in habit, fully justify separation. While *Ergasilus* is a parasite of the gills themselves, *Thersitina* attaches itself to the gill operculum.

* Giesbrecht (1882, p. 88) records its occurrence on the gills of Herring at Kiel.

Thersitina gasterostei, Pagenstecher.

(Figs. 1936–1947.)

1861. *T. gasterostei*, Pagenstecher, Arch. Naturg. XXVII, p. 120, figs.
1863. *Ergasilus gasterostei*, Kröyer, Nat. Tidsk. (3), II, p. 233, figs.
1892. *Thersites gasterostei*, Canu, Trav. Lab. Wim. VI, p. 245, figs.
1900. ,, ,, Scott, Rep. Fish. Bd. Scot. XVIII, p. 146, figs.
1901. *Ergasilus biuncinatus*, Gadd, Medd. Soc. Faun. Fenn. XXVII, p. 98.
1904. ,, ,, Gadd, Acta Soc. Faun. Fenn. XXVI, No. 8, p. 11, figs.
1913. *Thersitina gasterostei*, Gurney, Ann. Mag. Nat. Hist. (8), XII, p. 415, figs.
1913. ,, ,, Scott, T. & A. British Paras. Cop. I, p. 42, figs.

Mature female.—Length about ·6 mm.

Cephalothorax greatly swollen, almost spherical, the somites of legs 1 and 2 completely fused with it. Th. som. 5 very narrow, sometimes fused on dorsal side with som. 4. Genital somite as wide as long, and longer than rest of abdomen with rami. Furcal rami about as wide as long, with 4 setæ, the innermost very long and not jointed at base. Of the other 3, two are short and slender, the third inserted dorsally and diverging outwards.

Antennule of 5 segments. Setæ of seg. 1 mostly short, and so closely packed as to be difficult to count. Apparently there is the same number as in *E. sieboldi* (as given by Markewitsch), assuming seg. 1 = segs. 1 and 2 of the latter, namely 14, 5, 4, 2, 7. Seg. 4 has, as in *Cyclops*, also a delicate sensory hair. Antenna a large prehensile organ of 4 segments; basal segment very short, seg. 2 about twice as long as wide; seg. 3 short, bearing a curved spine; seg. 4 a curved claw. Mandible with a strongly toothed blade and a forwardly-curved toothed process. Maxillule a small knob-like appendage with 3 short setæ. Maxilla with large basal part, and a freely movable distal segment strongly toothed at end. Maxillipede absent. Basis of legs 2–4 with double row of small spines on inner part, and without inner setæ. Rami of all legs, except exopod of leg 4, 3-segmented; numbers of setæ on segments as in *E. sieboldi*, as follows:

	Exopod.				Endopod.		
Leg 1 . . .	0	1	5	.	1	1	4
Legs 2, 3 . . .	0	1	6	.	1	2	4
Leg 4 . . .	0	5		.	1	2	3

Leg 5 a small papilla with one apical seta.

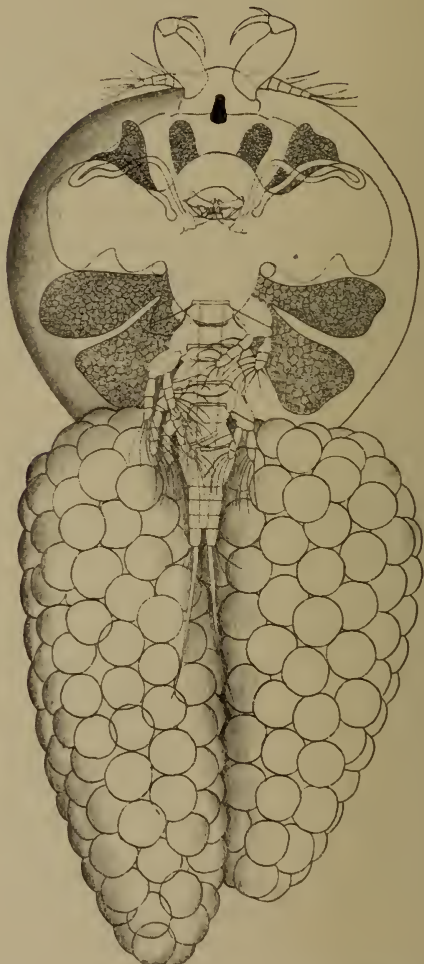
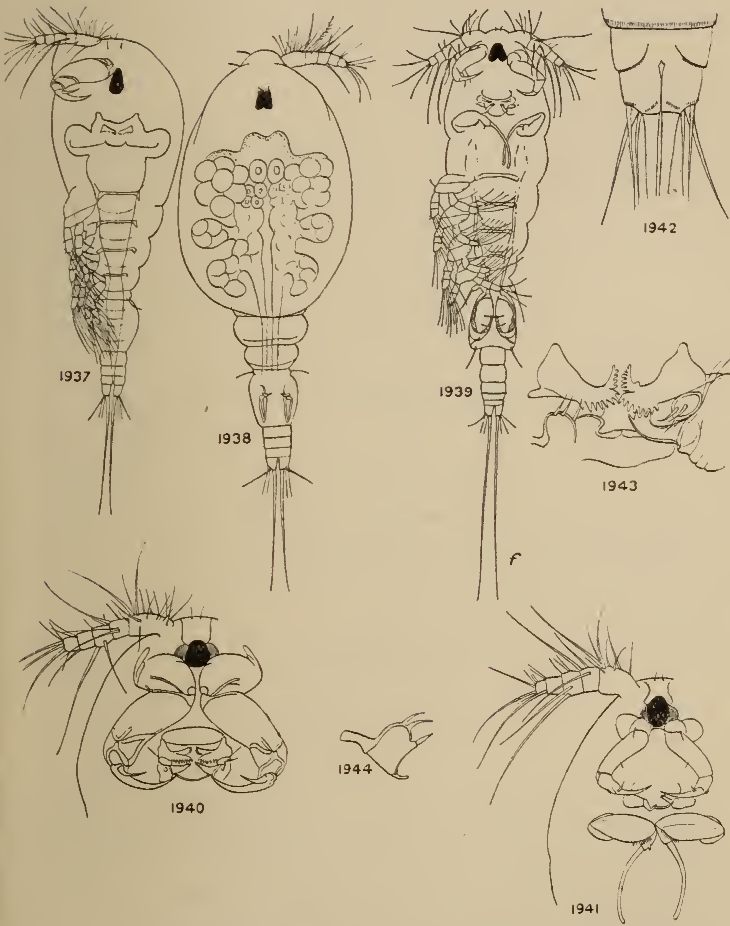


FIG. 1936.—*Thersitina gasterostei*, mature female, ventral.



FIGS. 1937–1944.—*Thersitina gasterostei.*

FIG. 1937.—Young female, just fixed to host, ventral.
FIG. 1938.—Young female, thorax swelling, dorsal.
FIG. 1939.—Adult male.
FIG. 1940.—Head of young female, ventral.
FIG. 1941.—Head of male, ventral.
FIG. 1942.—Furcal rami, free-swimming female, ventral.
FIG. 1943.—Mouth-parts, adult female.
FIG. 1944.—Maxillule separated.

Egg-sacs very large, longer than whole body.

Colour: Body colourless, but walls of intestine and its large lateral pouches contain blue pigment.

Male.—Length 1·0 mm.

The male differs from the free-swimming female in its greater slenderness, the form of the genital somite, and possession of a large prehensile maxillipede.

Distribution in Britain.

Scotland: Outer Hebrides, Forth, Aberdeen, Loch Etive (Scott).

England: Norfolk; Yarmouth, Cley (R. G.).

Distribution Abroad.

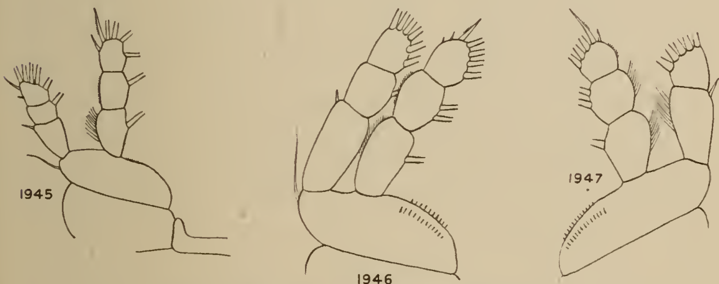
Greenland and Faröes (Kröyer).
Belgium: Ostend (Pagenstecher).
Denmark (Kröyer).
France: Wimereux (Canu).
Holland: Texel, Hook (R. G.).

Bionomics.

Found abundantly under the gill-covers of Sticklebacks (*Gastrosteus aculeatus* and *G. pungitius*) in brackish water. In ditches near Yarmouth I find it has a marked preference for *G. aculeatus* as compared with *G. pungitius* when both fishes occur together. The copepod attaches itself to the mucous lining of the operculum, and not, as a rule, to the gills. As many as 40 have been found under one operculum. When very numerous they may also be found on the gills, or even on the fins or tail.

The number of mature adults decreases markedly from August onwards, and in October females are without egg-sacs and usually with empty ovaries. It

seems that the last generation of young hatched in autumn fix themselves and pass winter and early spring without becoming mature, while the previous generation dies out. Reproduction begins in March, and continues throughout summer. I have supposed (Gurney, 1913) that five generations may be produced in the year, but am not now satisfied with the evidence. There seems no doubt that the first generation fixes and matures about end of May, while the winter generation dies off, but how many generations succeed between then and October is unknown.



FIGS. 1945–1947.—*Thersitina gasterostei.*

FIG. 1945.—Leg 1, male.
FIG. 1946.—Leg 3, female.
FIG. 1947.—Leg 4, female.

As fish and parasite inhabit small ditches where infection must be easy, almost every fish may be infected at certain times, and all available space on the opercula may be occupied by parasites. Although so numerous, the parasites are, apparently, quite harmless to the fish, no doubt owing to the fact that the gills are not attacked. The females appear to be fertilized once and for all in the free-swimming stage. Males, though very common during the summer, are never found in the gill-chamber of the fish.

Wilson states that in *Ergasilus* there is evidence for three generations in the year.

CALIGOIDA, Sars.

1901. *Caligoida* and *Lernæoida*, Sars, Crust. Norway, IV, p. 2.
1932. ,, *Lernæopodoida*, Wilson, Bull. 158, U.S. Nat. Mus. p. 397.

Parasites of fishes, or more rarely of Arthropods, Molluscs,* Amphibia and Whales, with sucking mouth cone enclosing the mandibles. Copepodid larva generally attached to host by a frontal filament.

The union of the Caligidæ and Lernæidæ is inevitable in view of their ontogeny and of the many transitional forms; but, if this is conceded, it is difficult to avoid the conclusion that all the fish parasites must be brought within a single Order. Wilson, in his latest work, makes two Orders, Caligoida and Lernæopodoida, and includes the Chondracanthidæ in the latter. The Chondracanthidæ, however, seem to stand apart. Their mouth-parts are quite different, and their relationship seems to be with the Ergasilidæ, as Wilson himself has previously suggested. It is true that the male resembles that of some Lernæopodidæ in general appearance; but this may be explained as merely due to arrested development, and consequent independent assumption of attachment to the female. The ontogeny is not known, beyond the nauplius stage, which is free in *Chondracanthus*. The Lernæopodidæ hatch in the Copepodid stage. The position of the Philichthyidæ is uncertain. Claus's account of the structure of *Philichthys* and *Lernæascus* points to relation to the Chondracanthidæ; but Quidor (1910) has described a chalimus stage in *Leposphilus*, and concludes that the Philichthyidæ are intermediate between the Lernæidæ and Dichelesthiidæ.

Oakley includes all these forms, with the exception of the Chondracanthidæ and Juanettiidæ, in one group, Caligiformes, and with this conclusion I agree. Within this group, however, some subdivisions may be made, though the gaps between them are very narrow. The

* See Monod and Dollfus (1932), *Anchicaligus nautili* (Willey) on *Nautilus*; *Pennella varians*, St. & Lütk. on Cephalopods; *Cerastocheres trochicola*, M. & D., on *Trochus*.

Lernæopodidæ seem to be isolated from the rest, but, if the Sphyriidæ are taken into account, it becomes difficult to separate them. This family has hitherto been regarded as related to the Lernæidæ, but Wilson has now (1932) made known the copepodid of *Pœon*, and this larva possesses the coiled frontal filament so characteristic of the Lernæopods. The mouth-parts are also almost identical with those of the Lernæopods. Wilson, therefore, now includes the Sphyriidæ in his Order Lernæopodoida. But the adult female has traces of 4 pairs of legs, and the body is elongated as it is in the Lernæidæ, the general form closely resembling *Lernæogiraffa*, for example. If, then, the Sphyriidæ are to be grouped with the Lernæopodidæ, it becomes difficult to draw any distinction between this group and the Lernæiformes. Perhaps the most satisfactory arrangement is to leave the Sphyriidæ with the Lernæiformes, and to keep the Lernæopods separate by reason of their abbreviated development and unique method of attachment.

Series 1. Caligiformes.

Parasites of fishes as a rule. Males not differing greatly from female, and attached independently to same host. Eggs in linear series in egg-sac.

Caligidæ.
Dichelesthiidæ.

CALIGIDÆ.

1905. Wilson, Proc. U.S. Nat. Mus. XXVIII, p. 532.

Cephalothorax forming a broad flattened disc, and commonly including somites of legs 2 and 3 ; antennule with basal part fused with head to form a frontal plate, which may bear suckers ; antenna prehensile ; maxillule vestigial ; maxillipede strongly prehensile ; legs 1–4 well developed, biramous, or legs 1 and 4 uniramous ; genital somite compounded apparently of soms. 5 and 6, very large. With chalimus stage, attached by frontal filament except in Euryphorinæ.

Subfamily **CALIGINÆ**, Wilson.

1905. Wilson, Proc. U.S. Nat. Mus. XXVIII, p. 532.

Eyes fused in middle line; somites of legs 1–3 fused with cephalothorax; legs 1 and 4 uniramous.

Development.

(Figs. 1948–1958.)

The development of *Caligus* and *Lepeophtheirus* has been described by A. Scott (1901), Wilson (1905) and Russell (1925).

Nauplius and Copepodid Stages.

Lepeophtheirus thompsoni, Baird.

Nauplii of this species were hatched from the egg at Plymouth, and were kept alive to the copepodid stage. The nauplii moulted within about 24 hours, but without change of external structure. The second nauplius showed the appendages of the copepodid under the cuticle, and moulted again about a day later. During these nauplius stages the mouth and anus were not open.

Nauplius.

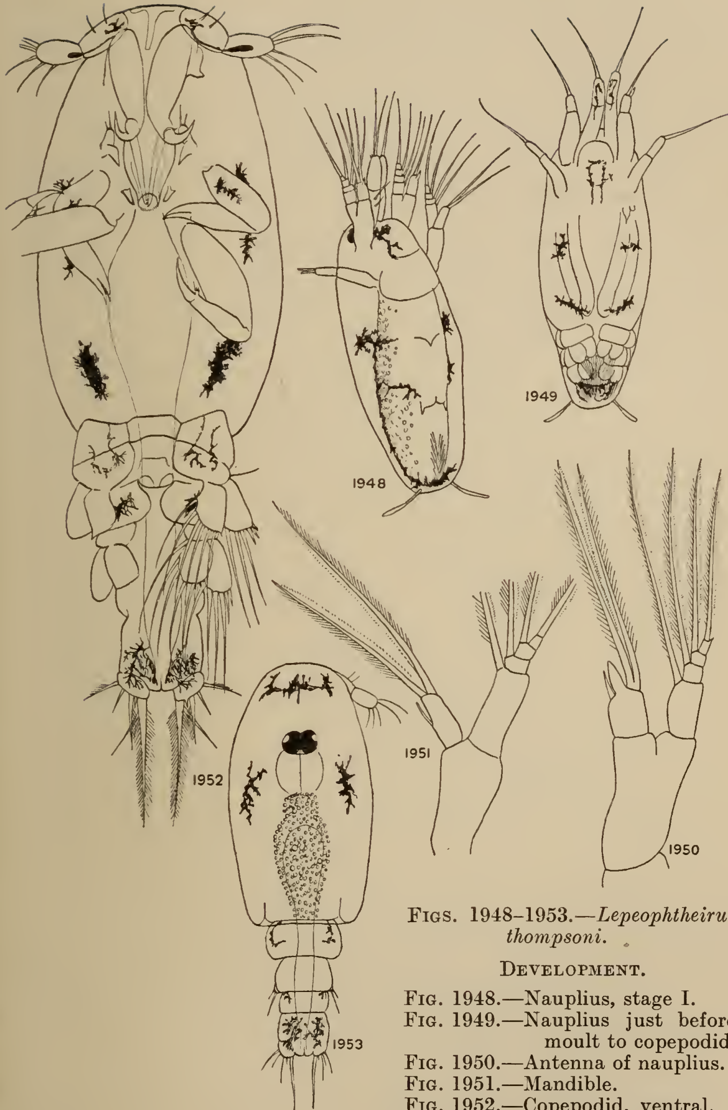
Length ·57 mm. Body very elongated, almost cylindrical, a little compressed laterally; labrum marked off faintly, but apparently not free. Antennule with 2 stiff apical setæ with serrated hyaline borders. Antennæ and mandibles with exopods of 4 segments, bearing 4 setæ; these setæ have a serrated hyaline membrane along one side and delicate feathering on the other. Furcal setæ divergent, cylindrical at base, but flat and blade-like at end.

Colour: Deep blue in well-defined spots.

Copepodid.

Copepodid: Length ·8 mm.

Body very slender, the cephalothorax about twice as long as hind body. Eye very large, placed rather

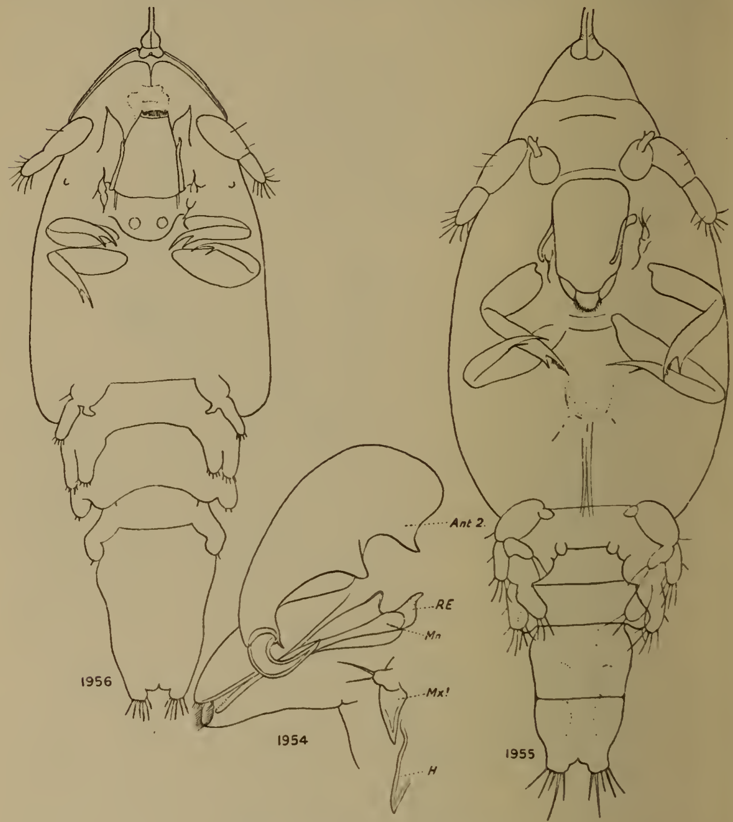


Figs. 1948–1953.—*Lepeophtheirus thompsoni.*

Development.

Fig. 1948.—Nauplius, stage I.
Fig. 1949.—Nauplius just before moult to copepodid.
Fig. 1950.—Antenna of nauplius.
Fig. 1951.—Mandible.
Fig. 1952.—Copepodid, ventral.
Fig. 1953.—The same, dorsal.

far back. Somites of legs 2, 3 and 4 free, followed by one somite and short, broad furcal rami, with 4 terminal setæ. Antennule of 2 segments. Antenna a large pre-



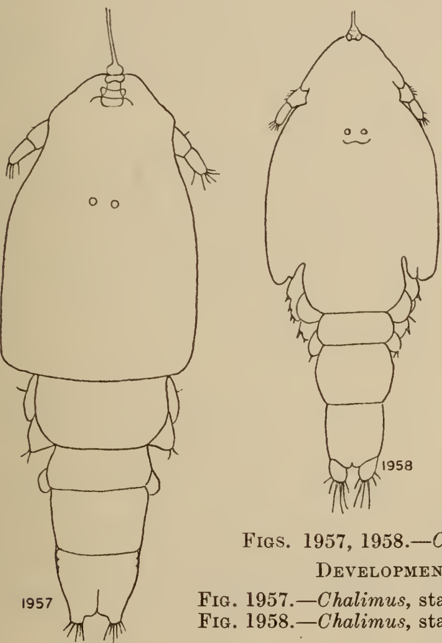
Figs. 1954–1956.—*Caligidæ.*

Development.

Fig. 1954.—Copepodid. Antenna and mouth cone. *Ant.*, antenna; *Mn.*, mandible; *R.E.*, exopod of mandible; *Mx.'*, maxillule; *H.*, post-maxillular spine.
Fig. 1955.—*Chalimus*, stage 1, ventral.
Fig. 1956.—*Chalimus*, stage 2.

hensile organ, with terminal claw. Oral cone consisting clearly of upper and lower lip, separated at base to allow insertion of mandible; mandible with vestige of exopod.

Maxillule, maxillæ and maxillipedes much as in adult. There is no trace of the post-antennal spines (first maxillæ of Scott), but there is a pair of spines behind the oral cone of unknown homology. They can hardly represent the future furca, since they seem to disappear at the next moult. Legs 1 and 2 well developed, with unsegmented rami and long setæ. Leg 3 a rudiment with 2 setæ.



FIGS. 1957, 1958.—*Caligidæ*.
DEVELOPMENT.
FIG. 1957.—*Chalimus*, stage 3, dorsal.
FIG. 1958.—*Chalimus*, stage 4, dorsal.

According to Wilson there are two copepodid stages, but Russell states that it is the first copepodid which seeks a host, and attaches itself by means of a frontal filament after the moult to the chalimus stage. The number of chalimus stages is uncertain. Wilson states that there are at least 5 moults, whereas Russell found 3 stages only. I am indebted to Dr. Russell for specimens of these attached stages belonging to an unnamed species of *Lepeophtheirus* from young Whiting, about 20 mm. long, taken in the young-fish trawl at Plymouth.

These fall certainly into three, and possibly into four stages.

Stage I: Length ·85 mm.

Cephalothorax more than $1\frac{1}{2}$ times as long as hind body, bearing leg 1; somites of legs 2 and 3 free. With fixation a process of degeneration of the antennæ and legs sets in. At this stage the antenna consists of a large basal segment and a minute cylindrical distal segment. Legs 1 and 2 are biramous, but the rami bear very much reduced setæ; basal segment with a small lobe of unknown homology. Leg 3 represented by a lobe bearing 2 setæ.

Stage II: Length 1·42 mm.

Somite of leg 2 fused with cephalothorax; somite of leg 3 large, that of leg 4 faintly marked off from hind-body. Antenna reduced to a conical body with minute apical spine. Leg 1 uniramous, the endopod represented by a small lobe. Leg 2 bilobed, with minute setæ. Legs 3 and 4 rudimentary.

Stage III (?): A specimen of 1·7 mm. with rather larger rudiment of leg 3 may represent another stage, but more probably an individual variation, or another species.

Stage IV (?): Length 2·13–2·55 mm.

Thorax beginning to assume adult form, and including somite of leg 3. Somite of leg 4 free, followed by large genital somite, and unsegmented abdomen. Ontogeny offers no clue to the nature of the "genital" somite. The fact that it bears a vestigial appendage in the adult, and that there may be 4 abdominal somites in addition (*Caligus aliuncus*, Wilson), points to its being a fusion of the somite of leg 5 with abd. som. 1 (or th. som. 6). This view is supported by the fact that these two somites may fuse in the Ergasilidæ; but it is difficult to understand how leg 5 can then come to be at the end of the somite. Possibly leg 5 is lost and the vestigial appendage seen is leg 6. In any case it is worth noting that apparently abd. som. 2 does not form part of the gen. somite as it distinctly does in the female of *Cyclops*.

Legs beginning to re-develop. Legs 1 and 4 uniramous but leg 1 with vestige of endopod. The sternal fork appears, in the form of two widely separated protuberances. This is the last chalimus stage. At the next moult the larva frees itself from the frontal filament, but probably one or more moults is required before the adult form and size are reached. In most cases, apparently, the chalimus fixes itself to its final host (Wilson, Scott); but the larvæ dealt with here, from very small Whiting (*Gadus merlangus*), must seek a new host. It is suggested by Russell (1933) that the attachment of the larvæ to these small fish may be accidental, and that their apparently strong preference for Whiting is due to the association of young Whiting with the jellyfish *Cyanea.* The Copepods may be attracted by a passing shadow; they may congregate under the *Cyanea* and there find the Whiting. Of 620 young Whiting examined only 35 bore *Caligids*—a fact which seems to show that the association is rather casual than normal.

LEPEOPHTHEIRUS, Nordmann.

1832. Nordmann, Mikrog. Beit. p. 30.
1905. Wilson, Proc. U.S. Nat. Mus. XXVIII, p. 615.

Frontal plate without suckers; mandibles toothed on inner margin only; maxillule forked.

Type.—*L. pectoralis* (Müller).

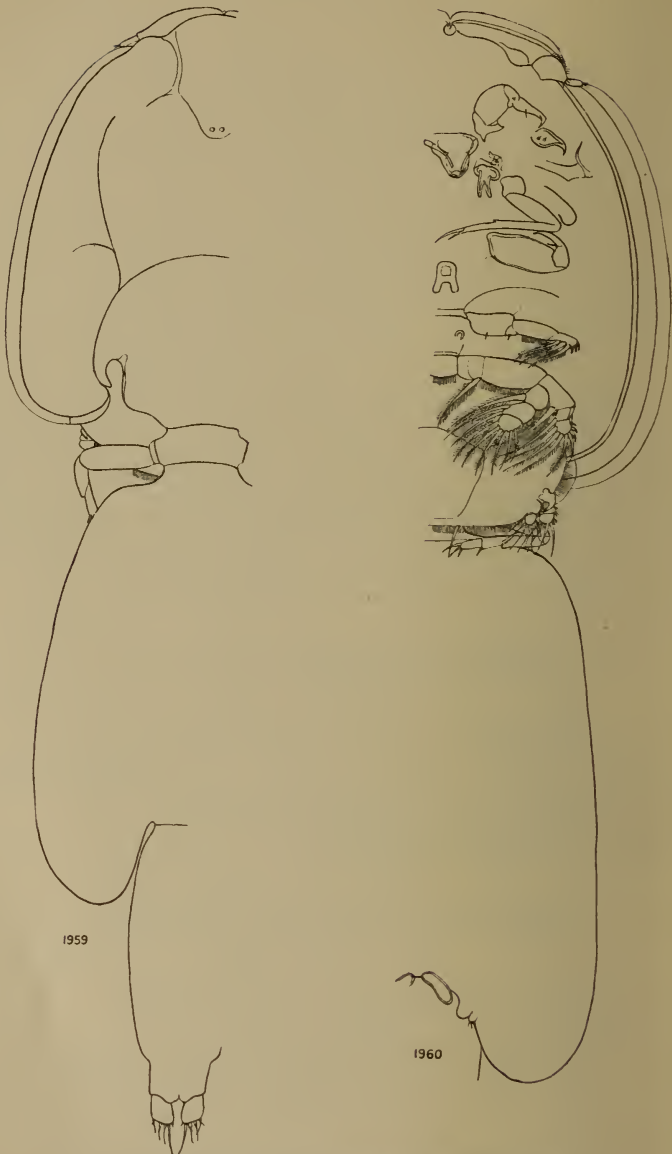
Lepeophtheirus salmonis (Kröyer).

(Figs. 1959–1968.)

1838. *Caligus salmonis,* Kröyer, Naturh. Tidsk. II, p. 13, figs.
1840. *C. vespa,* M. Edwards, Hist. Nat. Crust. III, p. 456.
1850. *L. stromii,* Baird, N. H. Brit. Ent. p. 274, figs.
1900. ,, Scott, Rep. Fish. Bd. Scot. XVIII, p. 152, figs.
1905. *L. salmonis,* Wilson, Proc. U.S. Nat. Mus. XXVIII, p. 640, figs.
1913. ,, T. & A. Scott, Brit. Par. Cop. p. 71, figs.

Female.—Length 13–16 mm. Egg-sacs 25 mm.

Carapace nearly as wide as long, and but little shorter than som. 4 and genital somite; genital somite very



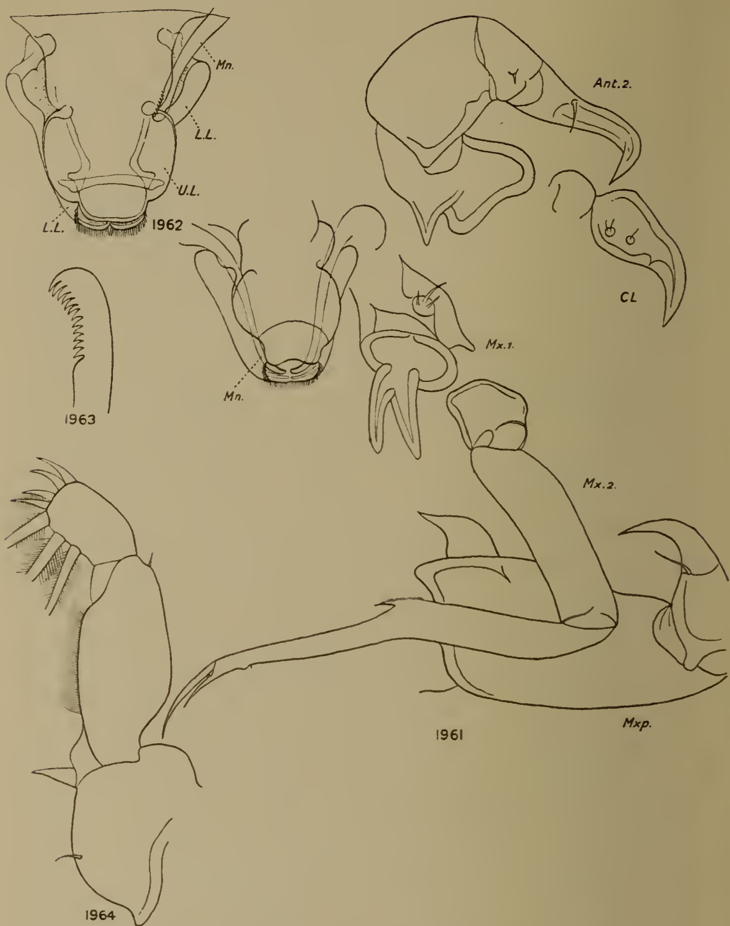
1959

1960

FIGS. 1959, 1960.—*Lepeophtheirus salmonis.*

FIG. 1959.—Female, dorsal. FIG. 1960.—Female, ventral.

large, widening behind, and with posterior corners produced backwards as rounded lobes ; abdomen long and narrow, unsegmented, but constricted distally ; furcal rami short and broad, with short setæ which are rarely completely evaginated ; free somite small, less than half width of genital somite. Antennæ robust, with terminal claw longer than basal segment. Wilson states that the basal segment lacks the spine on posterior margin, but it is present in my specimens. Mandible with 12 recurved spines on distal inner margin. Lying on outer side of antenna is a strong curved spine, with 2 papillæ at base bearing delicate hairs. This is regarded by Wilson, Scott and Oakley as the maxillule, but it can be shown in ontogeny, and by comparison with the appendages of Ergasilidæ (Gurney, 1927, p. 465), that these hooks are not true appendages. Maxillule in form of a strong bifurcate spine lying alongside the mouth cone, and with a papilla at its base bearing 3 setæ. Maxilla of 3 segments, the first very small, the third very slender, twice as long as second, and bearing 2 terminal claws ; anterior margin of seg. 3 with comb-like structure. Maxillipede consisting of a very large basal segment, and a short distal segment bearing an inner seta and a stout terminal claw. Sternal fork with small, blunt, and somewhat divergent branches. Leg 1 uniramous ; seg. 1 with small seta on posterior face, and stout terminal spine ; seg. 3 with 3 long setæ, 1 very short flattened seta and 3 terminal spines. Leg 2 biramous, each branch with 3 segments ; exopod with 5 feathered setæ and 3 outer spines, of which the distal one is very large. Leg 3, basal segments united across middle line and bearing a broad striated membrane, the whole continuing the line of the carapace, and completing the sucker-like form of the disc ; endopod of 3 segments, the first bearing a large ventral inbent claw ; endopod of 2 segments. Leg 4 of 4 segments, seg. 1 as long as segs. 2–4 together ; seg. 2 without spine ; seg. 4 with 3 terminal spines ; leg 5 a small plate bearing 3 setæ.



FIGS. 1961–1964.—*Lepeophtheirus salmonis.*

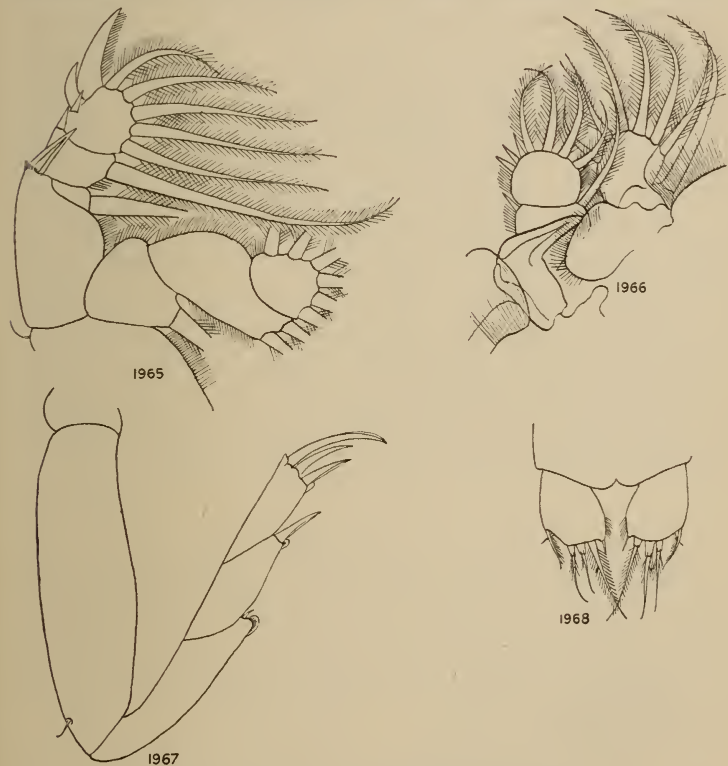
FIG. 1961.—Mouth region. *Ant.* 2, antenna; *Cl.*, post-antennal claw; *Mn.*, mandible; *Mx.* 1, maxillule; *Mx.* 2, maxilla; *Mxp.*, maxillipede.
FIG. 1962.—Oral cone. *Mn.*, mandible, partly withdrawn, absent on right side; *L.L.*, lower lip; *U.L.*, upper lip.
FIG. 1963.—Tip of mandible.
FIG. 1964.—Leg 1.

Egg-sacs of remarkable length, about twice the whole length of the body.

Colour: Dark chocolate brown with metallic lustre.

Male.—Length 6–7 mm.

The male is figured by Baird and by Wilson, and described by T. & A. Scott. I have not seen it myself.



FIGS. 1965–1968.—*Lepeophtheirus salmonis.*

FIG. 1965.—Leg 2. FIG. 1967.—Leg 4.
FIG. 1966.—Leg 3. FIG. 1968.—Furcal rami.

DISTRIBUTION.

Common on Salmon, *Salmo salar*, throughout its range in Europe and North America. Also found on Sea Trout (*S. trutta*), and on Salmon of the genus *Oncorhynchus* in North America.

Bionomics.

The "sea louse" of salmon is constantly found on the fish on their return from the sea, and its presence is noted by anglers as proof that the fish is fresh-run. The lice are found, often in large numbers, in the anal region, where the skin of the fish becomes more or less inflamed by their activities. The lice commonly survive in fresh water about a week, but often much longer. Hutton (1923) gives an example of a fish caught with lice upon it 14 days after it had been hooked and had broken away. If conditions are suitable for the fish to run straight up the river the lice may be carried very far up. For instance, in the Wye, fish are frequently taken above Hereford, 85 miles from the sea, with lice upon them (Hutton). The egg-sacs are said to break off within two days. The males survive longer than the females (Hutton), but females very greatly outnumber the males in fresh-run fish. Wilson found one male only in the collection of the U.S. Museum, and I find no males at all among a large number of females from fish taken in the Tay in August, 1932.

Series 2. Lernæiformes.

Parasites of fishes. Males free-swimming and fully developed, or not developing beyond first copepodid stage, and then attached to female; female generally very degenerate when mature, and attached to host by outgrowths of head or thorax. Eggs in one or more rows in egg-sac.

LERNÆIDÆ, Wilson (part).

1917. Wilson, Proc. U.S. Nat. Mus. LIII, p. 32.

Cephalothorax with horn-like processes embedded in tissues of host, these processes simple or bifurcate. Thorax greatly elongated, unsegmented in adult, sometimes showing signs of torsion. Antennæ slender, not chelate; without sucking mouth-tube; maxillipede present in both sexes; all legs retained in adult, legs 1–4

biramous. Male, and free-swimming female, with abdomen of 4 somites; abdomen of adult female unsegmented, with vestigial furcal rami bearing setæ. Eggs in egg-sac multiseriate.

Wilson includes four subfamilies in the Lernæidæ:

Lernæinæ.
Lernæenicinæ.
Lernæocerinæ.
Pennellinæ.

The Lernæinæ include the genera *Lernæa*, *Areotrachelus*, Wilson (= *Leptotrachelus*, Brian), and *Therodamas*, Kröyer. Of these, *Areotrachelus* is imperfectly known, and *Therodamas* does not appear to have been seen since its original description in 1863. Both structure and development of *Lernæa* is known, though the arrangement of the mouth-parts remains obscure. The differences between *Lernæa* and the other three subfamilies seem to be so profound that it would be better to regard it as forming a family opposed to the rest. Whether the two genera associated with it should also be separated from it is uncertain. The main differences are these, if it is compared with the best known genus, *Lernæocera*:

Lernæa.	*Lernæocera.*
Whole body elongated, with legs evenly spaced.	Posterior portion only elongated; legs close together in front.
Without sucking mouth-tube; maxillule vestigial; maxilla a masticatory appendage.	With sucking mouth-tube enclosing mandibles; maxillule vestigial; maxilla prehensile.
Maxillipede present in both sexes.	Maxillipede vestigial in female.
Egg-sacs short, with eggs multiseriate.	Egg-sacs long, filiform, eggs uniseriate.
At least 3 nauplius stages.	One nauplius stage only.
Copepodid stages free; 5 stages, without degeneration of appendages.	Copepodid attached by frontal filament; appendages degenerating during fixation.
Antenna of larva a slender appendage, with small hook.	Antenna a short, powerful clasping organ.

In view of these differences it is proposed to restrict the family Lernæidæ to the genera *Lernæa*, *Lernæogiraffa*, Zimmermann, *Dysphorus*, Kurz (and possibly also *Therodamas* and *Areotrachelus*), the Lernæenicinæ, Lernæocerinæ and Pennellinæ forming a distinct family Lernæoceridæ.

LERNÆA, Linnæus.

1746. Linnæus, Fauna Suecica, p. 367.
1822. *Lernæocera* (part), Blainville, Journ. Physique, XCV, p. 375.
1913. ,, T. & A. Scott, Brit. Par. Cop. p. 154.
1917. *Lernæa*, Wilson, Proc. U.S. Nat. Mus. LIII, p. 36.

Cephalothorax produced into horns of varying shape, usually paired, but occasionally triradiate; body slender, generally showing some trace of torsion, with pregenital prominence and short unsegmented abdomen; abdomen with vestigial rami. Antenna with claw; without prominent mouth-tube; mandibles without teeth; four pairs of biramous legs, and vestigial leg 5. Egg-sacs not very long, the eggs not in a single series. Larvæ without frontal filament.

Type.—*L. cyprinacea*, Linn.

It is unfortunate that Wilson (1917, p. 3) should have found it necessary, in accordance with the International Rules of Nomenclature (1905), to transpose the genera *Lernæa* and *Lernæocera*. In the twelfth edition of the 'Systema Naturæ' Linnaeus gives *L. branchialis* first in his list, and this species was, in the general practice up to 1905, taken as the type of *Lernæa*, leaving *L. cyprinacea* as type of *Lernæocera*, Blainville. With the adoption of the tenth edition as starting-point the accepted practice of a century was invalidated, for Linnæus, in that edition, placed *L. cyprinacea* first. This is but one of many examples of the confusion caused by the Rules. Whether right or wrong according to these Rules, transposition of names with accepted meanings should not be permitted in any circumstances whatever, for nothing but unending confusion can result. In this case to return to the old usage can only

make matters worse, and I use the genus *Lernæa* in the new sense with profound regret. Perhaps another century of use will invest it with an established meaning.

Of this genus 23 species have been described, distributed as follows: Europe 3, Asia 1, Africa 9, North America 9, South America 1. The Asiatic species (*L. elegans*) seems to be identical with the European *L. cyprinacea.*

The species are not entirely restricted to fishes, for *L. cyprinacea* has been found on a Salamander in Japan, and Stunkard and Cable (1931) have described a new species (*L. ranæ*) from the tadpoles of the frog *Rana clamitans* in Ohio.

Development of Lernæa.

The nauplius of *L. esocina* was well figured by Nordmann, and the complete development of *L. cyprinacea* (as *L. elegans*) is described by Nakai (1927). Wilson also gives an excellent account of the larvæ of *L. variabilis.*

There are three nauplius stages only, the first of oval form, without mouth or labrum, and with a single pair of simple furcal setæ. Antennæ and mandibles without masticatory processes, and with exopods of 4 segments. Colour transparent, or light green.

The third moult produces the first copepodid, with 2 pairs of legs, a somite with rudimentary leg 3, and 2 legless somites. Mouth-parts as in adult. There follow four copepodid stages (three according to Wilson). The first copepodid may immediately seek the gills of an intermediate host, to which it fastens by antennæ and maxillipedes. The attachment is easily loosened, and the larva can swim freely. In the fifth stage the sexes are mature, and mating takes place. According to Wilson the male does not leave the temporary host, but the females, at this stage, seek the final host. Nakai found that the whole development may take place on

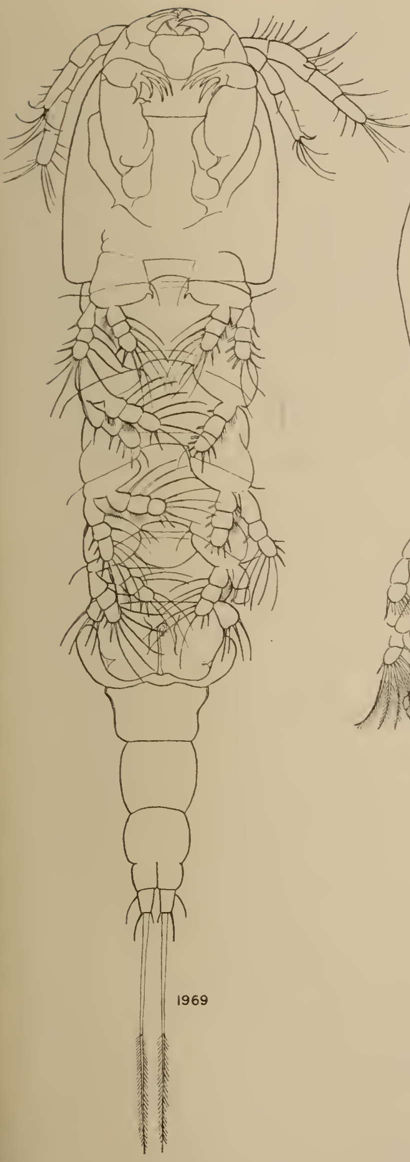
the same host. The time from hatching to production of egg-sacs is from 14 to 28 days, according to temperature (Nakai). The young female grows rapidly, by elongation of the thoracic somites, the cephalothorax and abdomen remaining but little enlarged. The egg-sacs and rudiments of the horns appear 5–8 days after fixation, the dorsal horns appearing first, but not becoming bifurcated till later. Wilson (1918) found much the same relation between the copepodid and the *Glochidia* of mussels as in the case of the *Ergasilidæ* (see p. 316), that is to say *Glochidia* did not attach themselves freely or at all to the gills of fishes already occupied by copepod parasites, and *vice versâ*. I am indebted to Mr. Matsui for specimens of the free-swimming female, but have not seen the earlier stages. A figure is given here of the corresponding stage in *Lernæocera*, at which the female (after fertilization) leaves the first host and becomes a free-swimmer, in order to show how great is the difference in development in the two genera.

Lernæa cyprinacea, Linn.

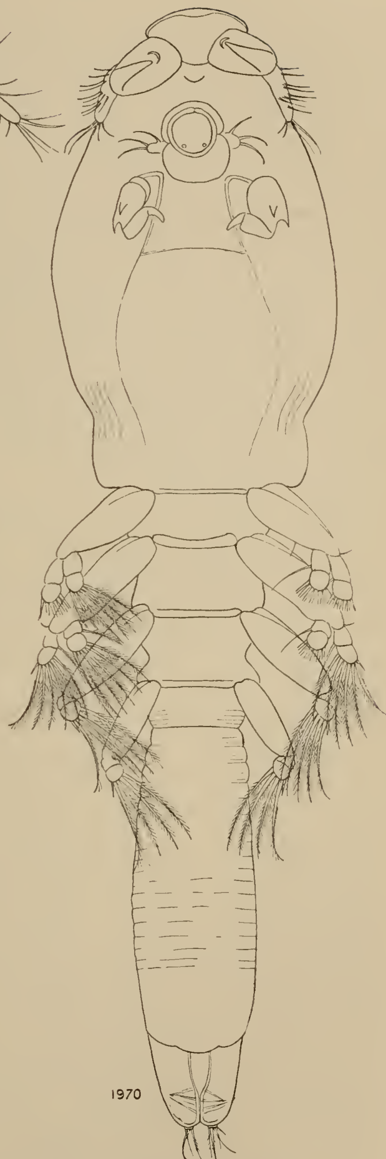
(Figs. 1969–1983.)

1758. *L. cyprinacea*, Linnæus, Syst. Nat. ed. 10, p. 655.
1783. ,, Barbut, Gen. Vermium, p. 67, figs.
1822. *Lernæocera cyprinacea*, Blainville, Journ. Phys. XCV, p. 377.
1833. ,, ,, Burmeister, Acta Acad. Caes. Leop. XVII, p. 309, figs.
1850. ,, ,, Baird, Nat. Hist. Brit. Ent. p. 342, fig.
1913. ,, ,, T. & A. Scott, Brit. Par. Cop. p. 154, figs.
1917. *Lernæa cyprinacea*, Wilson, Proc. U.S. Nat. Mus. LIII, p. 4.
1925. *L. elegans*, Leigh-Sharpe, Parasitol. Cambridge, XVII, p. 245, figs.
1928. ,, Matsui & Kumada, J. Imp. Fish. Inst. Tokyo, XXIII, p. 101, figs.

T. & A. Scott treat *L. cyprinacea*, Linn., and *L. esocina*, Burm., as possibly synonymous, and reproduce figures from Nordmann, Baird and Seligo under the same name. But Nordmann's species is distinct from that of Linnæus, and was renamed *L. esocina* by Burmeister. This distinction is generally accepted,



1969



1970

FIG. 1696.—Free-swimming female of *Lernœa cyprinacea*.
FIG. 1970.—Free-swimming female of *Lernœocera branchialis*.

and is confirmed by Cunnington (1914, p. 821), after examinations of both species, including one of the original specimens studied by Nordmann.

There does not seem to be any reason to distinguish *L. elegans*, Leigh-Sharpe, from *L. cyprinacea.* Leigh-Sharpe laid particular stress on the presence of a pair of "auricular expansions" of the head, and on a swelling of the body at the end of a narrow neck. Matsui and Kumada have not found these expansions, and their figures agree very well with the European form. Leigh-Sharpe also described a pair of appendages behind the maxillipedes, and in addition to the normal number of legs ; but these appendages have not been seen again. I am greatly indebted to Dr. Matsui for specimens of the Japanese form, and am unable to distinguish them from *L. cyprinacea.*

Mature female.—Length about 9 mm.

Cephalothorax produced into four horns, rather variable in length ; the anterior ventral pair simple, the dorsal pair T-shaped, the anterior branch longer than the posterior. Head projecting as a small round prominence between the arms. Body very slender, widening distally, with a foot-shaped end, the heel formed by the pregenital prominence, and the toe by the unsegmented abdomen. Furcal rami present, generally without setæ. Antennule of 4 segments, the second showing trace of subdivision ; seg. 4 with 7 apical setæ. Antenna of 3 segments, seg. 3 much longer than seg. 2 and with inner apical claw. Mouth-tube absent. A small pointed, or sometimes trifid, projection, which Wilson regards as rostrum, but is probably upper lip, overhangs the mouth. A large lower lip closes the oral space behind the maxillæ, and is completely separated from the upper lip. The structure of the mouth-parts is not satisfactorily established. Claus (1868) described a mandible, in the form of a small sickle-shaped appendage without teeth, and 2 other appendages which he called maxilla and maxillipede. Wilson mentions, and figures, another appendage, with one claw, in front of the maxilla,

FIGS. 1971–1983.—*Lernæa cyprinacea.*

FIG. 1971.—Mature female, dorsal.
FIG. 1972.—Horns of another female from same fish.
FIG. 1973.—Cephalothorax of free female, dorsal.
FIG. 1974.—Ventral view of mouth region, free female.
FIG. 1975.—Antennule, female.
FIG. 1976.—Antennule, male.
FIG. 1977.—Antenna, male, segs. 2 and 3.
FIG. 1978.—Leg 1, female.
FIG. 1979.—Leg 1, male.
FIG. 1980.—Leg. 2.
FIG. 1981.—Leg 4.
FIG. 1982.—Leg 5.
FIG. 1983.—Furcal ramus, mature female.

and Nakai's description (1927) seems to agree with that of Wilson. It is extremely difficult to make out the structures lying in front of the maxillæ, which are large unsegmented appendages with 2 large apical claws, entirely covering maxillule and mandible. If the maxillæ are removed a structure which appears to be a vestigial maxillule is found, in the form of a pair of small spineless flaps. The mandibles are very small, overhung by upper lip and covered by maxillule, and can only be seen with difficulty. They are simple curved stylets, with enlarged base. Maxillipedes at some distance behind mouth, indistinctly segmented; seg. 1 with inner papilla bearing a small seta; seg. 2 with 5 strong claws. Legs 1–4 very minute, but biramous, each branch of 3 segments. Leg 1 placed just behind the arms; legs 2–4 widely spaced along body, their position sometimes showing some torsion of the body to the right. Leg 1 with stout spine on inner corner of basis; each leg with inner seta on coxa; legs 2–4 with 2 setæ on seg. 2 of endopod. Leg 5 of 2 segments; seg. 1 with small seta; seg. 2 with 4 setæ.

Egg-sacs rather long and slender, but shape and size depending to some extent on age.

Free-swimming female.—Length ·7 mm.

Body of normal copepodid form; abdomen of 4, or commonly of 5 somites, soms. 1 and 2 completely separated. Cephalothorax divided dorsally into anterior and posterior regions by transverse chitinous bar, immediately behind which is a small "nuchal organ" (Fig. 1973). Furcal rami with dorsal and lateral setæ, and 3 apical setæ, the middle one very long, feathered in distal half. Appendages as in the mature form, except that the antennule has a 5th segment separated.

Male.—Length ·76 mm.

General form, and appendages, differing little from that of free-swimming female. Antennule rather indistinctly segmented, but apparently of 6 segments. Antenna a little stouter than in female, and with larger

claw. Leg 1 with claw on basis larger, and with small inner spine (Fig. 1979).

Distribution.

Baird records this species in his British list on the authority of Barbut, though he had not seen it himself; T. & A. Scott also include it on the same authority. Reference to Barbut's work affords no evidence that he, who was certainly acquainted with the animal, had actually seen it in Britain. Barbut was a Frenchman, and was no doubt giving his experience abroad. At the same time there is no reason why the species should not occur in this country. It is recorded from various parts of Europe (Scandinavia, France, Italy, Germany), and extends to Japan, if *L. elegans* is not accepted as a distinct species.

Bionomics.

Parasitic on the following fish: *Carassius vulgaris*, *Cyprinus carpio*, *Gobio fluviatilis*. In Japan on *Anguilla japonica*, *Carassius auratus*, *Pseudorasbora anguillicaudata* and *parva*, *Oryzias latipes*, *Plecoglossus altivelis*. Also on a Salamander (*Diemyctelus pyrrhogaster*) (Okada, 1927). Excellent accounts of development and relation to host are given by Matsui and Kumada and by Nakai (1927). In Japan the parasite has increased and spread to such an extent as to be a serious menace to fish-culture. It was first found to be causing damage to eels, in this case choking the mouth-cavity, but it is also found on other fish, burrowing with the head under the scales. The most favourable temperature for development was found to be 14–32° C., the eggs failing to hatch at 36° C., and the larvæ to reach maturity at 14° C. The only satisfactory method for destroying the parasite was found by Nakai to be treatment with a solution of bleaching powder containing ·0001% of available

chlorine. A concentration of ·0005% is lethal to fish, but not to the adult parasite, so that effective attack can only be made on the larvæ during spring. By this method some control has been established.

Series 3. ACHTHERIFORMES.

Parasites of fishes. Neither sex developing beyond first copepodid stage. Female attached by arms representing modified maxillæ. Dwarf males attached to females.

LERNÆOPODIDÆ, Milne Edwards.

1840. *Lerneopodiens*, Milne Edwards, Hist. Nat. Crust. III, p. 505.
1915. *Lernæopodidæ*, Wilson, Proc. U.S. Nat. Mus. XLVII, p. 598.

Sessile parasites of fishes, usually without free nauplius stage and becoming mature in first copepodid stage. Head generally separated by deep constriction from body, in which segmentation is either absent or faintly marked; antennæ not used for prehension; upper and lower lips forming a sucking tube in which mandibles are enclosed; maxillæ modified as organs of attachment, generally fused at tips; maxillipedes generally with strong claws; legs absent. Egg-sacs large, the eggs not arranged in a single row.

Males small, clinging to body of female, but with some power of locomotion. Maxillæ remaining as short, clawed appendages.

Wilson divides the family into the following subfamilies:

Lernæopodinæ.
Tracheliastinæ.
Brianellinæ.
Clavellinæ.

Only the first two contain fresh-water genera.

Development of Lernæopodidæ.

The larvæ of *Achtheres* have been fully described by Claus (1861) and Wilson (1911a), and have also been figured by Nordmann (1832) and others. Fasten (1913) has given an account of the larva of *Salmincola edwardsi*, while Wilson figures the first free larva of *Clavella uncinata*. I have examined some much decayed larvæ of *S. salmonea*, which were obtained from a female kept for three days in fresh water after being taken from a salmon caught in the Tay estuary in August, 1932.

In *A. percarum*, according to Nordmann, there is a free nauplius with 2 pairs of appendages only, but in *A. ambloplitis* the nauplius stage is passed in the egg, and the larva hatches as a copepodid. This is also the case in *S. salmonea*. The first copepodid is of elongated form, resembling that of *Caligus*, with a large eye seated far back on the dorsal surface (Fig. 1992). Behind the cephalothorax, which bears leg 1, are 4 somites, corresponding to legs 2–4, and an unsegmented abdomen. The furcal rami are very short and broad, resembling those of *Caligus*. The antennule is 4-segmented in *Achtheres* and *Salmincola*, but 2-segmented in *Clavella*, and turned backwards as in *Caligus*. Antenna short and stout, with prehensile hook. The mandibles are said at this stage to be outside the mouth-tube. Dorsal to the mouth-tube is a long coiled filament which is destined to be everted and to serve for attachment to the host. The mouth-parts are more or less of adult form. There are two pairs of biramous swimming-legs. Development does not proceed any further, the larva attaching itself to the host in this first stage. The adult is therefore a pædogenetic first copepodid. The resemblance to the Lernæidæ and Caligidæ is close. All have the same form of copepodid, with mouth-tube and filament for attachment, though it is not certain that the filament is homologous in the two cases; but, in the Lernæidæ and Caligidæ, the attachment by filament is a temporary stage, and development proceeds much further. The

process of attachment to the gill has been observed by Fasten in *S. edwardsi*, a parasite of *Salvelinus fontinalis*. The free-swimming stage lasts only about 2 days, during which the copepodid does not feed, but swims actively in spirals. When contact is made with the gill the larva holds on with maxillæ and maxillipedes, and the former rasp a hole in the gill-filament. Into this hole the end of the frontal filament is inserted, and it becomes embedded by the regenerating tissues. The larva is for a time attached by the head, but later the maxillæ detach the filament from the head and become permanently fixed to it (Fig. 2033). How the bulla develops into its final form, and how the filament itself disappears, so that the maxillary arms are attached to the bulla by a small pedicel, is not known. Fasten (1931) states that the larvæ of *Salmincola edwardsi* are at the surface by day and at the bottom at night, as its host is. Maturity is reached $2\frac{1}{2}$ weeks after fixation, and the female dies after producing two broods.

LERNÆOPODINÆ, Wilson.

1915. Wilson, Proc. U.S. Nat. Mus. XLVII, p. 603.

Female.—Cephalothorax shorter than arms (maxillæ), and in line with body or bent forwards ; body with or without posterior processes, but without anal laminæ (furcal rami). Maxillæ situated outside maxillipede, and both close to base of mouth-tube ; maxillæ united only at tips, sometimes separated.

Male.—Cephalothorax separated from body by deep groove ; body often segmented and comparatively slender ; anal laminæ present, generally directed backwards ; antennæ biramous, with claw on endopod.

The following genera are included by Wilson :

Salmincola, Wilson. Parasitic on Salmonidæ.

Achtheres, Nordmann. On Salmonidæ, Percidæ and Siluridæ.

Lernæopoda, Blainville. On Elasmobranchs.

Lernæopodina, Wilson. On Elasmobranchs.
Basanistes, Nordmann. On Salmonidæ.
Vanbenedenia, Malm. On *Chimæra*.

SALMINCOLA, Wilson.

1915. Wilson, Proc. U.S. Nat. Mus. XLVII, p. 603.

Cephalothorax short, without dorsal carapace, inclined at an angle from the body, from which it is separated by a deep groove. Body without segmentation and without anal laminæ. Antennules unsegmented or with traces of 3 segments ; antenna biramous, endopod with small claw ; maxillule with 3 spines ; maxillæ* forming stout arms, joined at end by a mushroom-shaped bulla, the base sometimes continued across the back of the cephalothorax as a prominent ridge ; maxillipede with slender terminal claw. Egg-sacs generally long and slender with numerous small eggs, not in a single row.

Male small ; cephalothorax about as long as body, without dorsal carapace ; body rather slender, bent forwards and indistinctly segmented, with very small anal laminæ bent backwards. Antennules 3-segmented ; antennæ biramous, endopod with claw ; maxillæ and maxillipedes strong, chelate.

Type.—*S. salmonea* (Gissler).

The establishment of this genus, which includes only species parasitic on Salmonidæ, leaves the genus *Lernæopoda* with but few species, confined to Elasmobranchs. From *Lernæopoda* it differs in the female in the absence of a genital process and other characters, while the male of the latter is distinguished by its larger size, and particularly by the very large anal laminæ (Fig. 1994). From *Achtheres* it is, however, separable with difficulty, and the male is almost identical in the two genera.

* The arms are regarded by T. & A. Scott and others as maxillipedes. Their position in development and the fact that the maxillary gland is connected with them (Claus) shows them to be maxillæ (see Fig. 2045). This is Wilson's view.

Salmincola salmonea (Linn.).

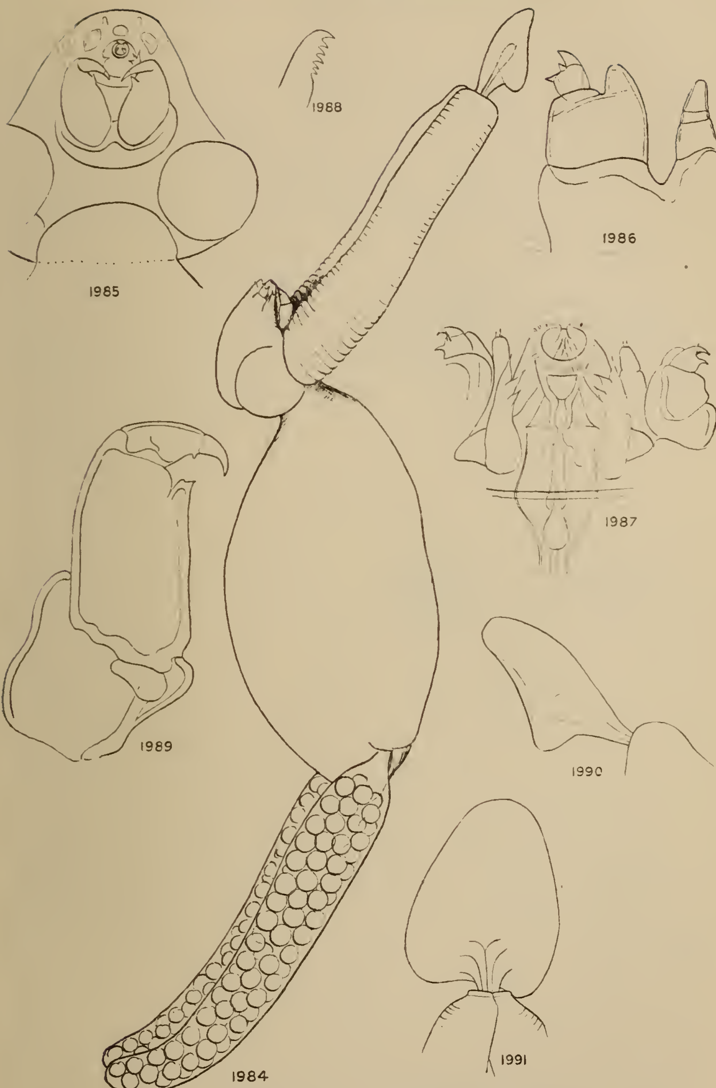
(Figs. 1984–1995.)

1758. *Lernæa salmonea*, Linnæus, Syst. Nat. ed. 10, p. 655.
1780. ,, Cordiner, Antiq. and Sc. Scotland, p. 7, figs.
1783. *Lernæopoda cyprinacea*, Hermann, Der Naturforscher. Halle, no. 19, figs.
1816. *Schisturus salmoneus*, Oken, Lehrb. Nat. p. 183.
1818. *Entomoda salmonea*, Lamarck, Hist. Anim. ed. 2, p. 686.
1840. *Basanistes salmonea*, Milne Edwards, Hist. Nat. Crust. III, p. 509, figs.
1850. *Lernæopoda salmonea*, Baird, N. H. Brit. Entom. p. 335, fig.
1899. ,, ,, Bassett-Smith, Proc. Zool. Soc. p. 500.
1900. ,, ,, T. Scott, Rep. Fish. Bd. Scot. XVIII, p. 173, figs.
1904. ,, ,, Gadd, Acta S. Fauna Fl. Fenn. XXVI, no. 8, p. 28, figs.
1912. ,, ,, T. & A. Scott, Brit. Par. Cop. I, p. 199, figs.
1915. *Salmincola salmonea*, Wilson, Proc. U.S. Nat. Mus. XLVII, p. 607, figs.

Female.—Length 7 mm.

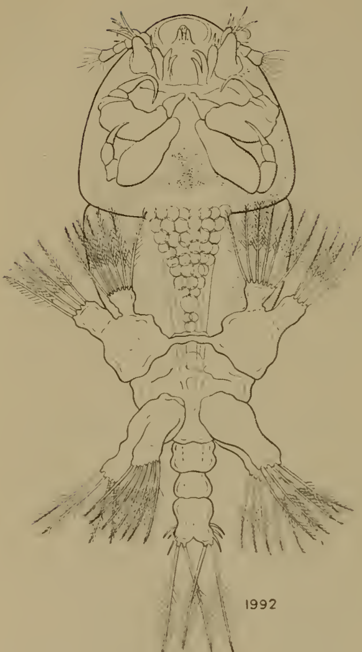
Cephalothorax triangular in dorsal view, the greatest width about equal to length; in side view arched dorsally; the whole turned slightly backwards from the axis of the body. Cephalothorax and hind-body separated by a deep constriction forming a short neck; hind-body showing traces of segmentation ventrally, and variable in form according to degree of maturity, but generally oval, greatest width about half length; a minute abdominal process present posteriorly. Antennule short and blunt, with trace of 3 segments; antenna stout, with unsegmented rami; exopod a simple papilla, endopod with 3 terminal spines. Maxillule with 3 terminal pointed processes and sometimes with traces of segmentation. Maxillæ long and slender, not dilated at ends, nearly straight, and about as long as body. They are joined at the tip by a pedicel to a large pear-shaped bulla, which is applied to, and not buried in, the tissues of the gill-filament. Maxillipede with basal part 2-segmented, seg. 2 with inner distal spinous process; terminal claw short and stout, with a small papilliform process on inner margin. Egg-sacs slender, about as long as hind-body.

Male unknown.

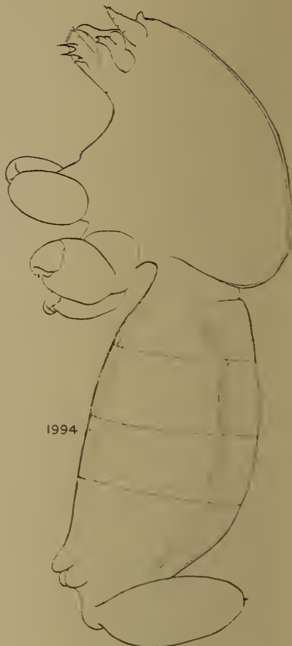


Figs. 1984–1991.—*Salmincola salmonea.*

Fig. 1984.—Female, adult, lateral.
Fig. 1985.—Head region, ventral.
Fig. 1986.—Antennule and antenna.
Fig. 1987.—Mouth-parts.
Fig. 1988.—Tip of mandible.
Fig. 1989.—Maxillipede.
Fig. 1990.—End of maxillary arms, with bulla, side view.
Fig. 1991.—Bulla, dorsal.



1992



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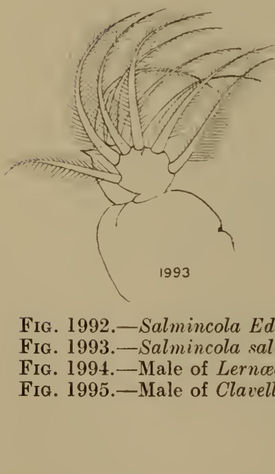
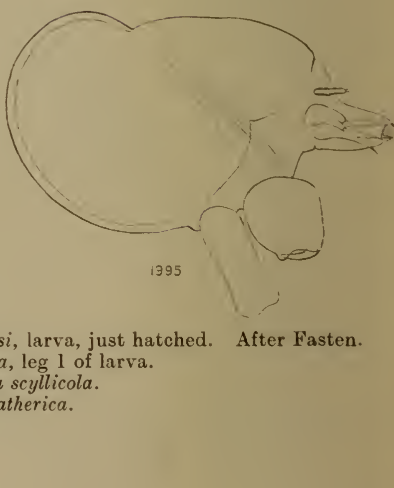


1993



1995

Fig. 1992.—*Salmincola Edwardsi*, larva, just hatched. After Fasten.
Fig. 1993.—*Salmincola salmonea*, leg 1 of larva.
Fig. 1994.—Male of *Lernæopoda scyllicola*.
Fig. 1995.—Male of *Clavella sciatherica*.

Distribution in Britain.

Scotland: Firth of Tay (Scott, R. G.).
Ireland (Thomson).
Northumberland (Brady).
Devonshire: Plymouth (Bassett-Smith).
Herefordshire: R. Wye (Pashley, Hutton).

Distribution Abroad

Germany (Neresheimer): On *S. salar* and *S. salvelinus.*
Finland (Gadd): On *S. salar* and *S. trutta.*
Jana Territory (Sars): On *S.* (*Onchorhynchus*) *lagocephalus.*
Bohemia (Frič).

Bionomics.

It is remarkable that so little is known of the life-history of the common "gill maggot" of Salmon. There appears to be general agreement that the parasite breeds only in fresh water, and that salmon become infected only in the rivers. Fish which descend the river after spawning (kelts) generally have the parasite in numbers on the gills. The maggots do not die in sea-water, and their presence on the gills of fresh-run salmon may be accepted as proof that the fish has already spawned in a previous year, and is returning to spawn again. Hutton (1923) states that the maggots on these returning salmon are larger than those on the kelts. Examination of a large number taken from fresh-run salmon in the Tay in August showed that about half of them bore eggs, while in one specimen the eggs were nearly ready to hatch. A few had the remains of empty egg-sacs, from which the eggs may have already hatched in sea-water. It seems probable that the parasite returns to the river ripe and ready to breed in the late summer, and that infection may take place as soon as the fish reach fresh water. Probably there is only one generation, the larvæ fixing in autumn only becoming mature during the stay of the host in the sea.

The absence of records of the male seems to suggest that fertilization is effected, and the male dies, before the salmon leave the rivers.

In this country *S. salmonea* seems to be strictly confined to the salmon. Mr. Malloch, whose experience of the game fish of Scotland is very extensive, tells me that it is not found on Sea Trout (*S. trutta*). Fasten found that *S. edwardsi* was limited to *S. fontinalis*, and that the larvæ definitely refused the gills of other fish when brought into contact with them.

Wilson states that the parasite feeds on the blood of the host, and that, when feeding, it uses the maxillipedes to cling closely to the gill while the mouth-tube is pressed against it and the mandibles pierce the tissues. The intestine, in living specimens, is black, no doubt owing to the contained blood.

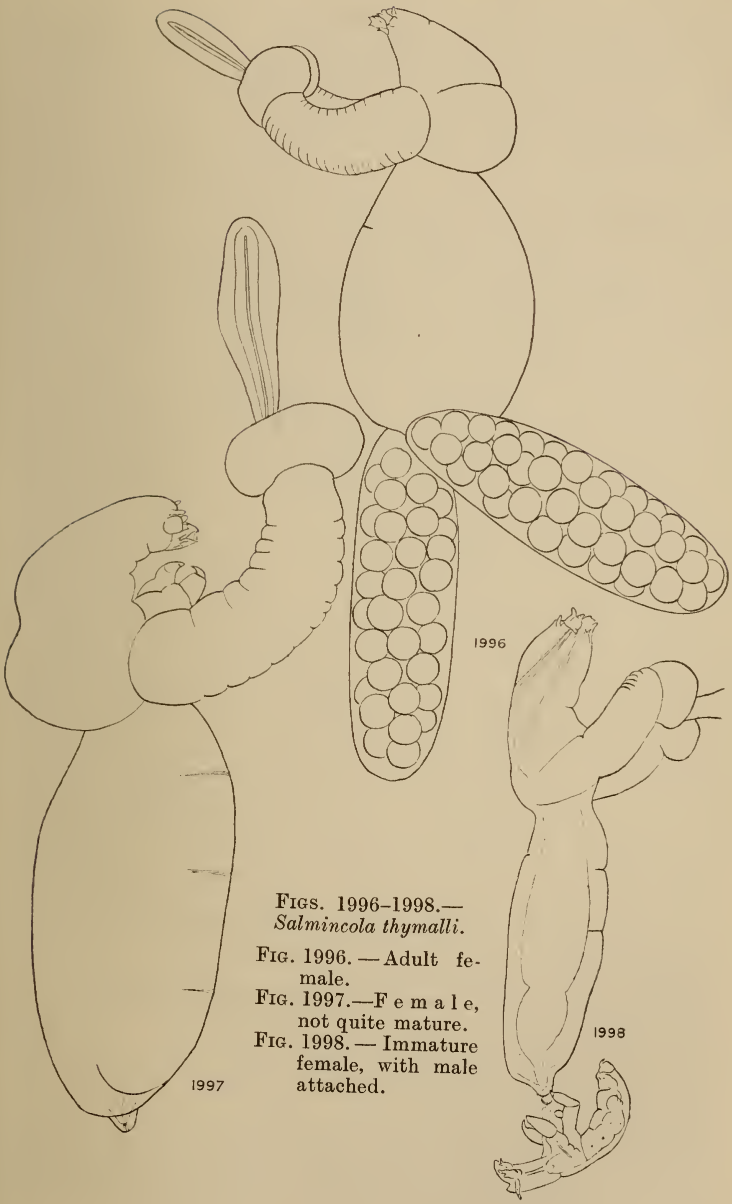
Salmincola thymalli (Kessler).

(Figs. 1996–2009.)

1868. *Lernaeopoda thymalli*, Kessler, p. 97, figs.
1872. *L. clavigera*, Olsson, Œfv. K. Svenska Vet. Akad. Forh. XXIX, no. 5, p. 63, figs.
1904. *L. thymalli*, Gadd, Acta S. Fauna Fl. Fenn. XXVI, p. 34.
1915. *Salmincola thymalli*, Wilson, Proc. U.S. Nat. Mus. XLVII, p. 613, figs.

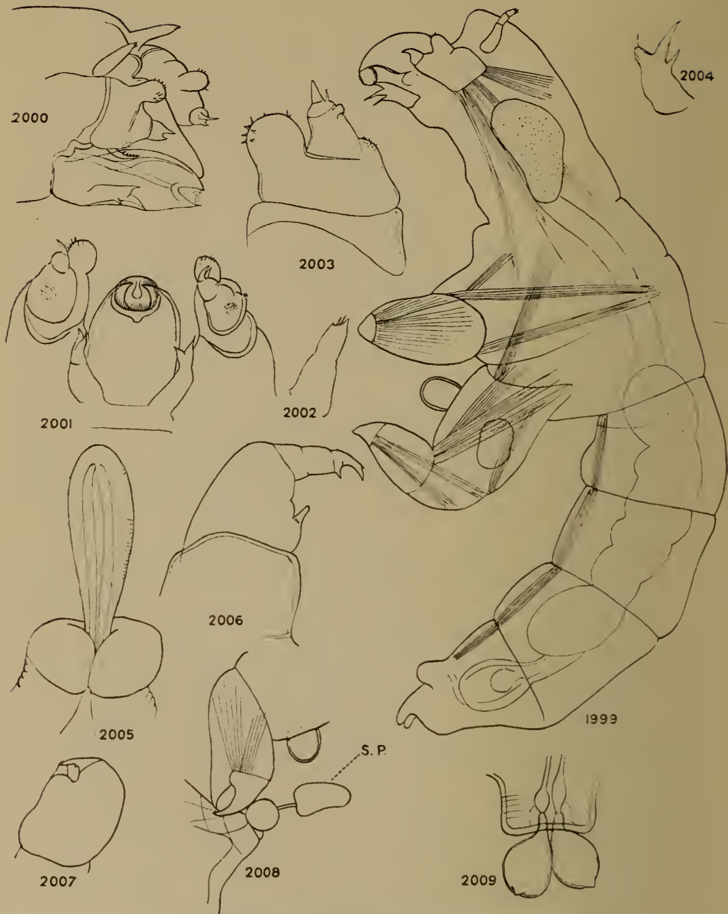
Female.—Length about 3 mm.

Cephalothorax in dorsal view triangular, greatest width about equal to length; in side view swollen at base at insertion of maxillæ, and bent slightly backwards. Hind body sharply constricted from cephalothorax, oval, with very faint traces of segmentation ventrally. The whole form changes much during life. In the young female, when first fixed (Fig. 1998), cephalothorax and body lie nearly in a straight line, and the former is not swollen at base. Later, the anterior part bends downwards, while the maxillary region dilates (Fig. 1997). Posterior end of body broadly rounded, with minute median papilla representing the "genital papilla" of Wilson. To this papilla the male clings, and to it the spermatophores are fastened (Fig. 2008). In the



FIGS. 1996–1998.—*Salmincola thymalli.*

FIG. 1996.—Adult female.
FIG. 1997.—Female, not quite mature.
FIG. 1998.—Immature female, with male attached.



FIGS. 1999–2009.—*Salmincola thymalli.*

FIG. 1999.—Male.
FIG. 2000.—Female, side view of head.
FIG. 2001.—Ventral view of mouth-tube, antennæ and maxillules.
FIG. 2002.—Antennule.
FIG. 2003.—Antenna.
FIG. 2004.—Maxillule.
FIG. 2005.—Swollen tips of maxillary arms, with bulla.
FIG. 2006.—Maxillipede.
FIG. 2007.—Maxilla of male.
FIG. 2008.—Maxillipede of male clasping female; showing spermatophore, *S.P.*
FIG. 2009.—Posterior end of adult female showing spermatophores or "round bodies."

specimen figured there was a pair of small round bodies similar to those figured by Claus in *Achtheres*, and also a pear-shaped spermatophore with slender stalk. The same round bodies have also been seen on an adult. Fasten states that these bodies are the shrunken, empty spermatophores.

Antennule a small unsegmented rod. Antennæ with stout conical base and vestigial exopod and endopod ; the former an unsegmented knob covered with small spines ; endopod obscurely 2-segmented, with two apical spines. Mandible sickle-shaped, enclosed within mouth-tube, with serrated tip. Maxillule a simple plate with 3 terminal pointed processes. Maxillary arms reaching just beyond head, curved forwards, and with tips greatly swollen. Bulla very elongated and narrow, deeply embedded in tissues of gill and firmly adherent to the axis of the filament. In the youngest specimen seen the bulla was fully as large as in the adult (about ·95 mm. long). Olsson also figures quite young females in which the bulla is of the same length as in the adult. Wilson says of the bulla : " All that is left of the filament is the button or bulla which joins the tips of the maxillæ and serves to anchor them firmly to the tissues of the host ", and that it is " composed of the hardened secretion of the frontal gland ". It is difficult to believe that the filament, or any part of it, can give rise to this large plate. It seems more likely that it is, in some way, the product of the arms themselves. A young female of *A. percarum* is shown in Fig. 2033, with filament of attachment. In this specimen no trace of a bulla could be seen at either end of the filament. Neresheimer supposed that the bulla contains two parallel tubes which are continued into the arms. The structures which appear as tubes may equally well be interpreted as chitinous thickenings. Maxillipedes nearly hidden between the arms in adult ; consisting of 3 segments ; seg. 2 with small inner peg-like process ; seg. 3 slender, with 2 terminal claws. Egg-sacs about as long as hind body, containing several rows of eggs.

Male.—Length 1 mm.

Whole body curved ventrally, the cephalothorax as long as hind body; head region narrow, marked off by a constriction from region of maxillæ and maxillipedes. Hind-body distinctly divided into 4 somites, corresponding to somites of legs 1–3, and an undivided thorax-abdomen. This last somite with a pair of terminal papillæ (anal laminæ of Wilson), and a pair of small rounded processes just in front of them on the ventral side. Antennule of 3 segments; antenna as in female, but endopod with small apical claw. Maxillæ apparently unsegmented, with short apical claw closing on a rounded process. Maxillipedes of 2 segments, the distal segment forming a powerful chela. A rounded process has the appearance of being attached to the basal segment, but may be a median process of the body similar to that of *Lernæopoda*.

Distribution in Britain.

I am much indebted to Mr. A. Gordon, of Helmsley, in Yorkshire, for specimens of this species from Grayling (*Thymallus vulgaris*) taken in the River Ray. In this river it is common on the Grayling, but not found on the Trout. Mr. Gordon tells me that it is seldom found on the fish in winter.

Distribution Abroad.

Finland (Kessler, Gadd): On *Thymallus vulgaris* and *Coregonus lavaretus*.

Sweden (Olsson, Wilson): On *T. vulgaris* and *Salmo alpinus*.

Salmincola gordoni, n. sp.*

(Figs. 2010–2020.)

1913. *Achtheres percarum*, T. & A. Scott, Brit. Par. Cop. p. 193, pl. 59, figs. 7, 8.

Female.—Length about 3 mm.

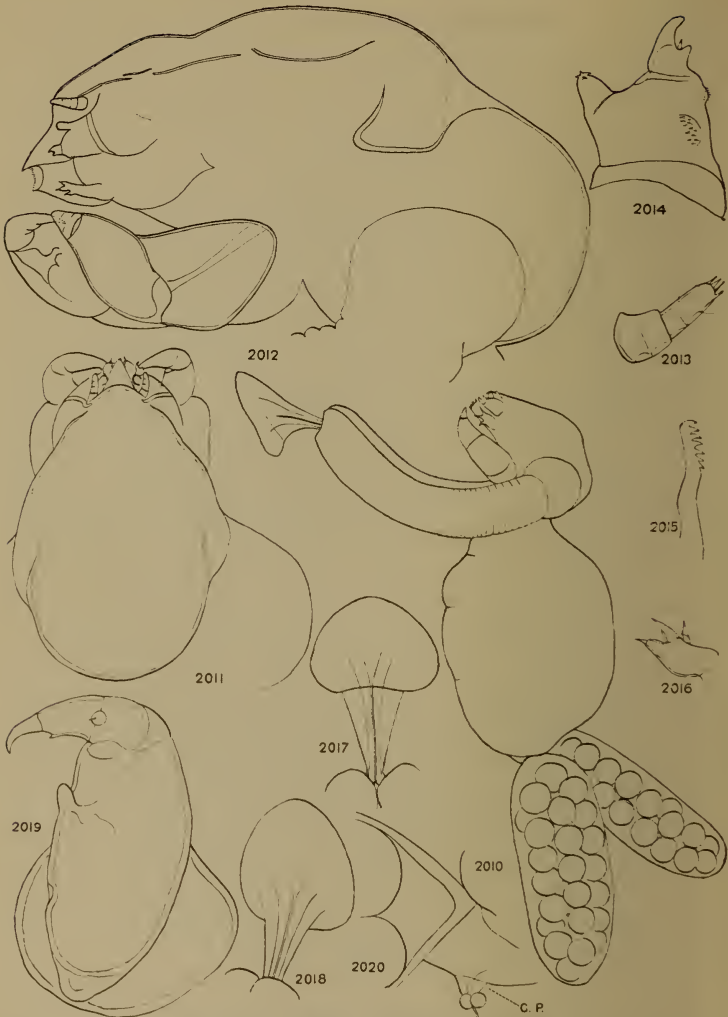
Cephalothorax, in dorsal view, forming a nearly equilateral triangle, the maxillary region much dilated. An area comparable to the so-called carapace of *Achtheres* is faintly marked out by cuticular thickenings visible only in cleared specimens. Hind-body short and oval, about $1\frac{1}{2}$ times as long as cephalothorax, with faint traces of segmentation ventrally. Posterior end with small genital process sometimes bearing " round bodies ". Antennule clearly 2-segmented, and with suggestion of 4 segments; apex with small spines. Antenna bent somewhat inwards towards mouth cone, biramous, the exopod small, conical, with a few small spinules; endopod unsegmented, with large apical claw, a small basal rounded spine and a small sharp spine between. Mandible with sinuate stem and about 7 terminal teeth. Maxillule with 3 spine-bearing processes. Maxillary arms much longer than cephalothorax, curving forwards, not dilated at tips. Bulla pedunculate, with large heart-shaped disc which adheres to gill or wall of gill-chamber, and is apparently not buried in tissues. Maxillipedes very large, reaching forwards to end of mouth-cone and 3-segmented; seg. 2 with inner peg-like process; seg. 3 partly divided into 2 segments, and with strong terminal claw. Egg-sacs not longer than hind-body.

Distribution.

On gills and on walls of gill-chamber of Trout and Grayling, River Ray, Yorkshire. Collected by Mr. A. Gordon.

On gills of Trout: Moray Firth, Loch Tay and Loch Awe in Sutherlandshire (T. & A. Scott).

* Named after Mr. A. Gordon, of Helmsley, who has taken much trouble to obtain material of this and the preceding species.



FIGS. 2010–2020.—*Salmincola gordoni.*

FIG. 2010.—Female, lateral.
FIG. 2011.—Cephalothorax, dorsal view.
FIG. 2012.—Cephalothorax, side view; specimen cleared in caustic potash.
FIG. 2013.—Antennule.
FIG. 2014.—Antenna.
FIG. 2015.—Mandible.
FIG. 2016.—Maxillule.
FIG. 2017.—Bulla from below.
FIG. 2018.—Bulla from above.
FIG. 2019.—Maxillipede.
FIG. 2020.—Posterior end of body, showing genital process. *G.P.*

This species is readily distinguished from *S. thymalli*, with which it is associated in the River Ray, by the large maxillipedes and the form of the bulla. It is certainly the same species as that described by T. & A. Scott as *Achtheres percarum*.

None of the thirteen species of *Salmincola* recorded from Europe or Asia have anything like the same form of bulla except *S. salmonea*, from which this species is distinguished by the very much larger cephalothorax. The two species are, however, very close in other respects, and it is possible that this species should be regarded as a subspecies, or even as the parent form, of *S. salmonea*.

ACHTHERES, Nordmann.

1832. Nordmann, Mik. Beitr. p. 63.
1915. Wilson, Proc. U.S. Nat. Mus. XLVII, p. 617.

Cephalothorax with triangular area marked off dorsally by chitinous thickening; body generally more or less distinctly segmented, and marked off from cephalothorax by a deep constriction; a small abdominal region marked off, and occasionally segmented (Wilson); without anal laminæ and genital process. Antennæ bent inwards across head. Maxillule with 3 terminal processes and lateral spine; maxillipedes between, and hidden partly or entirely by, maxillæ.

Male.—Cephalothorax in line with body axis; body segmented, with vestigial rami; maxillæ and maxillipedes chelate, the former larger than the latter; maxillipedes fused at base, with median rounded process.

Type.—*A. percarum*, Nordmann.

The genus, of which most of the species are American, differs so little from *Salmincola* that it is not easy to justify the separation of the latter. In Europe there are two species only, but of these *A. coregoni*, Baumann, is most doubtful. From the description it is identical with *A. coregoni*, Smith, from North America, but Baumann, after seeing one of Smith's specimens, regarded the species as distinct, without giving any reason for his opinion.

Achtheres percarum, Nordmann.

(Figs. 2021–2038.)

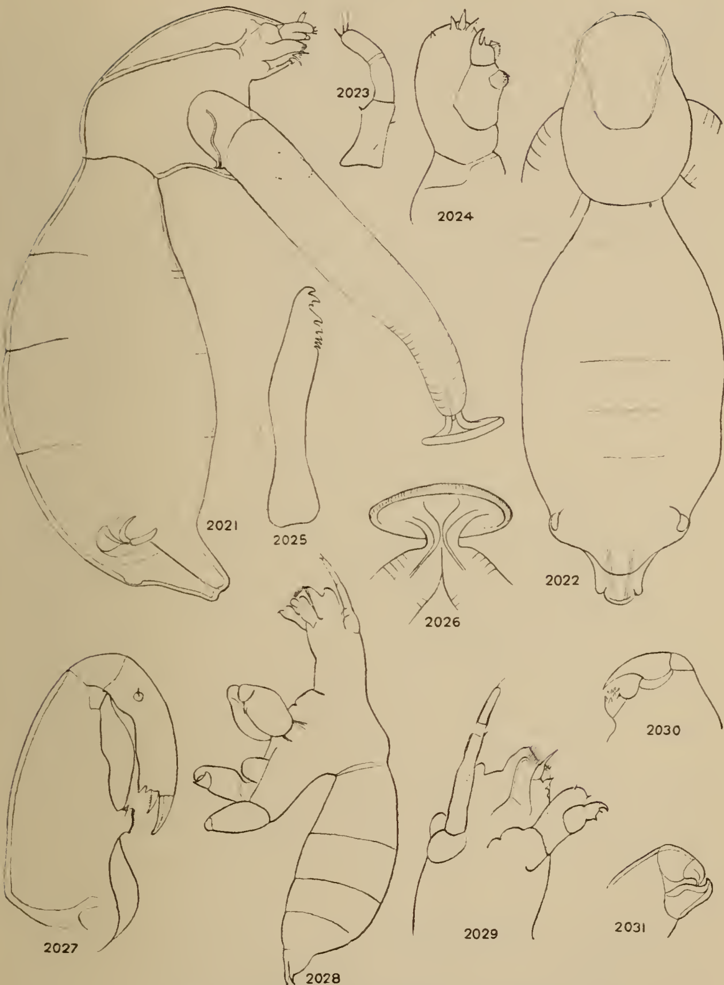
1832. *A. percarum,* Nordmann, Mik. Beitr. p. 63, figs.
1838. ,, Kröyer, Nat. Tidsk. II, p. 143, figs.
1862. ,, Claus, Zeits. wiss. Zool. XI, p. 287, figs.
1904. ,, and *A. sandræ,* Gadd, Acta S. Fauna Fl. Fenn. XXVI, no. 8, pp. 21, 22, figs.
1915. ,, Wilson, Proc. U.S. Nat. Mus. XLVII, p. 629, figs.
1926. *A. sibirica,* Messjatzeff, Arch. Naturg. XCII, Abt. A, p. 120, figs.
1932. *A. percarum,* Markewitsch, Zool. Anz. XCIX, p. 31, figs.

Female.—Length about 4 mm.

Cephalothorax in dorsal view more or less rectangular, squarely truncate in front, with chitinous ridge enclosing a triangular area (carapace of Wilson); in side view bent at an angle to body axis which may be as much as a right angle; not swollen dorsally in maxillary region. Hind-body oval, sometimes flattened dorso-ventrally, and generally distinctly segmented. Post-genital region (abdomen) conical, not segmented, trilobed in dorsal view (Fig. 2022), and often with a pair of rounded bodies attached (receptacula of Claus). In *A. sandræ* each of the lateral lobes is said to have a small jointed process, which Gadd considers to be a rudimentary appendage. In one specimen I have seen a similar process of the lobe on one side, but not on both.

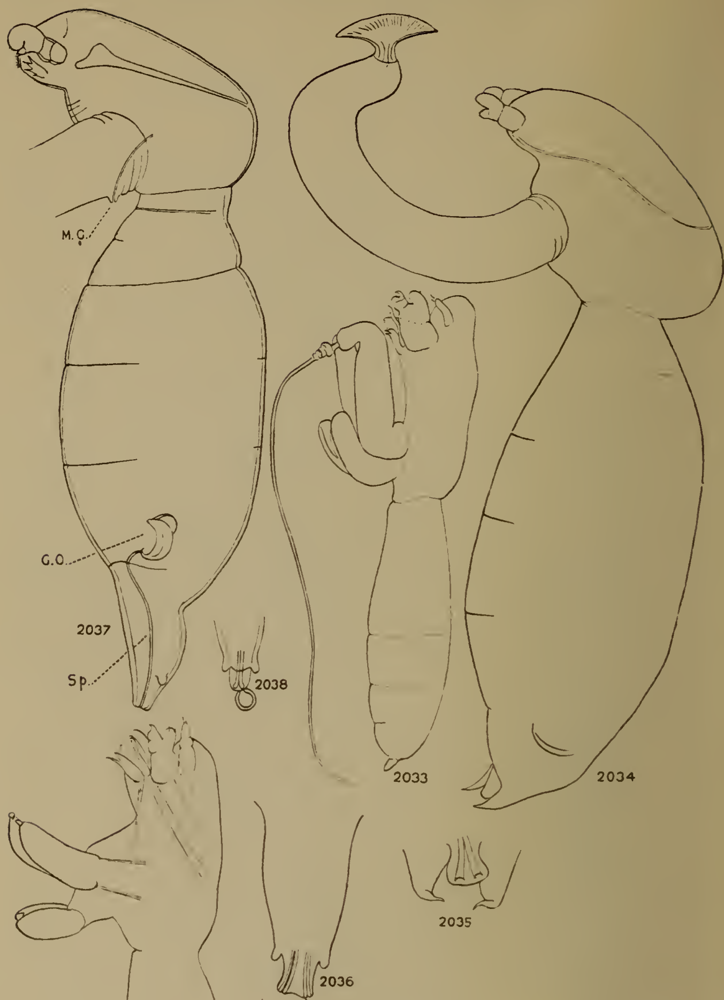
Antennule 3-segmented. Antenna with exopod larger than endopod, bearing 3 large apical spines; endopod of 2 segments with roughened pad on inner side of each segment and 2 apical spines. Maxillule with 3 apical processes and a small lateral process, each tipped with a spine. Maxillary arms long and slender, commonly directed backwards, tapering a little at end; bulla a circular disc. Maxillipede of 2 segments; basal segment with small spine and a roughened patch on inner side; seg. 2 with smooth terminal claw and 3 smaller spines, of which two are denticulate. Egg-sacs about as long as body, sometimes considerably shorter.

Male.—Length 2 mm.



Figs. 2021–2031.—*Achtheres percarum.*

Fig. 2021.—Adult female, lateral.
Fig. 2022.—The same, dorsal.
Fig. 2023.—Antennule.
Fig. 2024.—Antenna.
Fig. 2025.—Mandible.
Fig. 2026.—Bulla.
Fig. 2027.—Maxillipede.
Fig. 2028.—Male, adult.
Fig. 2029.—Male, side view of head, more enlarged.
Fig. 2030.—Male. Chela of maxilla.
Fig. 2031.—Male. Chela of maxillipede.



Figs. 2032–2038.—*Achtheres percarum.*

Fig. 2032.—Immature male.
Fig. 2033.—Immature female, with filament of attachment.
Fig. 2034.—Female, from *Lucioperca sandra*, Lake Ladoga.
Fig. 2035.—Abdomen of same, ventral.
Fig. 2036.—Abdomen of another specimen from same fish, dorsal.
Fig. 2037.—Female, from *L. sandra*, Constantinople. *M.G.*, opening of maxillary gland; *G.O.*, genital opening; *Sp.*, spermathecal tube.
Fig. 2038.—Abdomen of same, ventral.

Cephalothorax a little shorter than hind-body; head region narrow. Last somite of body constricted, with a pair of upturned pointed processes. Antennules long and slender, indistinctly segmented; 5 segments faintly indicated. Antennæ and mouth-parts as in female, but antennæ with fewer spines on exopod. Maxillæ and maxillipedes powerful chelate appendages, as in *Salmincola*. Basal segment of maxillipedes fused, with an unpaired median rounded process. An early stage of the male is shown in Fig. 2032. At this stage the maxillæ have very small terminal hooks, with which the filament of attachment is grasped for a time, until a female is found.

Distribution.

This species is recorded by T. & A. Scott from Scotland, but, as pointed out above (p. 359), the species they described was *S. thymalli*. It is therefore very doubtful if *A. percarum* actually occurs in this country. It is widely distributed in Europe, and recorded as far south as Genoa (Garbini) and as far east as Baikal (Messjatzeff). It is confined to the genera *Perca*, *Lucioperca* and *Esox*, and is found attached to the palate, tongue, gills, and other parts of the mouth-cavity, and also, less commonly, on the body surface. It is said to be very commonly covered with vorticellids, and has been found with *Cordylophora* growing on it (Borcea).

Markewitsch (1932) regards *A. sandræ*, Gadd, and *A. sibirica*, Messjatzeff, as identical with *A. percarum*. I have myself examined specimens of *Achtheres* taken from *Lucioperca sandra* from Lale Ladoga and from Constantinople, the former without doubt representing *A. sandræ*, Gadd, and agree there is no appreciable difference in the appendages. On the other hand, these specimens do differ considerably from typical *A. percarum* in the structure of the posterior end of the body. In those from Constantinople the "abdomen" is remarkably long (Fig. 2038), with a small lobe on either

side. In the specimens from Ladoga the abdomen is short, and flanked on either side by a large, downwardly curved process ending in a roughened spine, but not segmented as shown by Gadd. In one specimen the abdomen is elongated, and of precisely the same form as in the Constantinople specimens. In both cases the two openings leading to the sperm receptacle are very clear, and in one of them a round body is attached on one side. The lateral processes represent the furcal rami, which, in the typical form, are reduced to minute lobes, or absent. The form living on *Lucioperca sandra* does differ, either in the greater development of the abdomen, or in that of the rami; but it does not seem to require specific rank.

TRACHELIASTINÆ, Wilson.

1915. Wilson, Proc. U.S. Nat. Mus. XLVII, p. 644.
1931. Monod and Vladykov, Ann. Parasitol. Paris, IX, p. 211.

Cephalothorax narrow and cylindrical, generally shorter than the maxillary arms and generally more or less in line with body axis; hind-body unsegmented, without anal laminæ; maxillipedes much reduced, between, and hidden by, bases of maxillary arms, and seated far back from the head; arms united at tip to a small bulla, mushroom- or star-shaped.

Male unknown.

Containing the single genus *Tracheliastes*, Nordm.

TRACHELIASTES, Nordmann.

1832. Nordmann, Mik. Beitr. p. 95.
1835. Kollar, Ann. Wiener Mus. I, p. 82.
1931. Monod and Vladykov, p. 211.

With the characters of the subfamily.

Type.—*T. polycolpus*, Nordmann.

The genus contains five species:

T. polycolpus, v. Nordmann.

T. stellatus (Mayor, 1824) (syn. *T. stellifer*, Kollar, see Monod and Vladykov, 1931, p. 209).

T. maculatus, Kollar, 1836.
T. gigas, Richiardi, 1881.
T. grandis, Wilson, 1915.

Tracheliastes polycolpus, Nordmann.

(Figs. 2039–2047.)

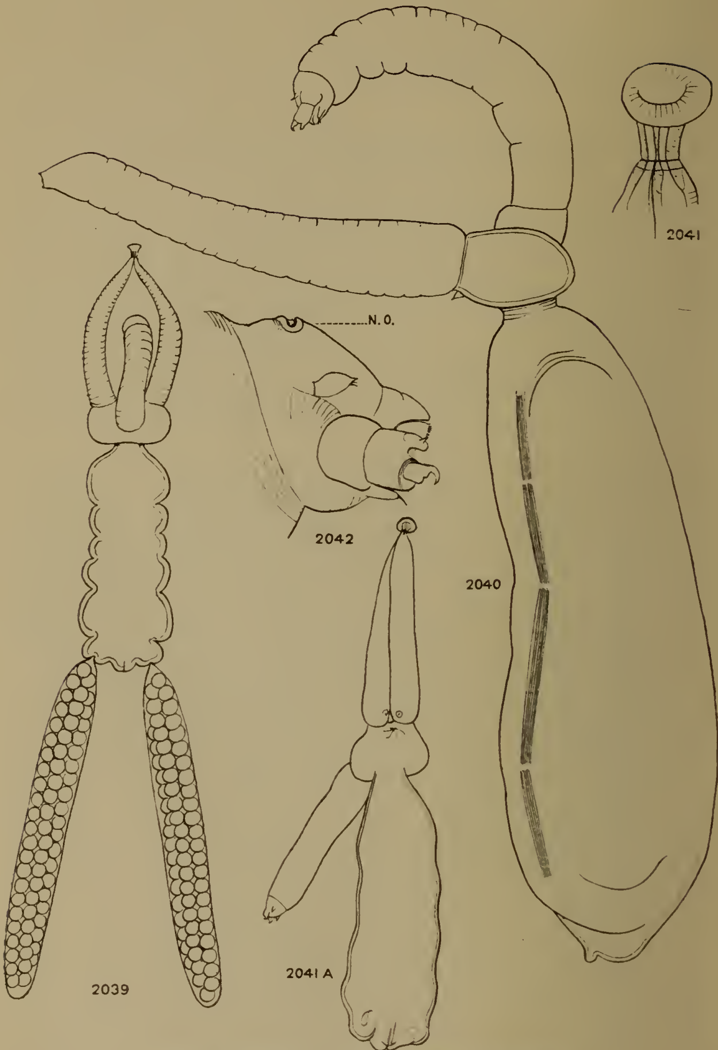
1832. *T. polycolpus*, v. Nordmann, Mik. Beitr. p. 95, figs.
1877. ,, and *T. phoxini*, Vejdovsky, Zeits. wiss. Zool. XXIX, p. 19, figs.
1904. ,, Gadd, Acta Soc. Fauna Fl. Fenn. XXVI, p. 39.
1928. *T. p. baicalensis*, *T. p. kessleri*, Messjatzeff, Arch. Naturg. XCIIA, p. 133, figs.
1929. *T. fecundus*, Odenwall, Mem. Soc. Fauna Fl. Fenn. 1929–30, no. 5, p. 80, figs.
1931. *T. polycolpus*, Monod, F., and Vladykov, V., Ann. Parasitol. Paris, IX, p. 204, figs.

Female.—Length about 5 mm.

Cephalothorax very long, cylindrical and flexible; arched forwards, as in Fig. 2040, or directed obliquely backwards. Head small, capable of partial retraction within the soft neck. In a specimen cleaned with caustic potash a depression was seen on the head corresponding to the "nuchal organ" of other copepods (Fig. 2042, *N.O.*). Hind-body broad, flattened dorso-ventrally, and thrown into folds along sides. As Kollar observed, these folds are not present when the ovaries are full. Posterior end broad, the oviducts opening widely apart on prominent lateral lobes. Antennule very small, unsegmented; antenna biramous, endopod unsegmented, with small terminal claw. Mandible enclosed within mouth-tube, with about 7 teeth on distal end; maxillule a very small, simple appendage with one apical seta. Maxillary arms very long, wrinkled, and united at tips to a small conical bulla, with circular disc. Maxillipede between bases of arms, very small, unsegmented, and tapering to a claw-like apex. Egg-sacs slender, as long as the whole body.

According to Nordmann the outer covering of the body is very transparent, but the body has a greenish tinge, while head region may be red.

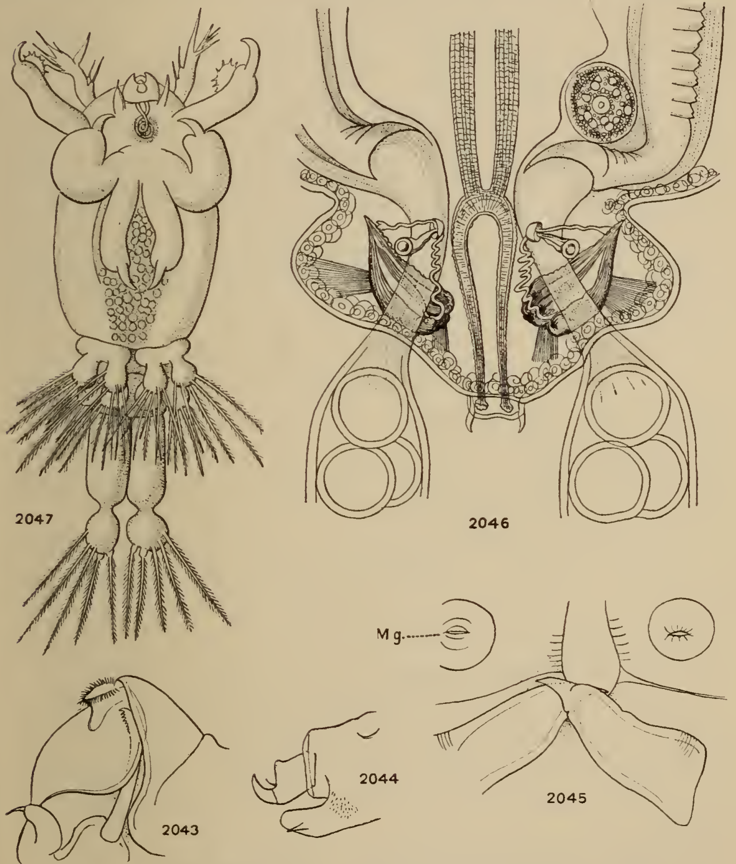
Nordmann observed the hatching of nauplii, with



FIGS. 2039–2042.—*Tracheliastes polycolpus.*

FIG. 2039.—Female, dorsal.
FIG. 2040.—Female, lateral.
FIG. 2041.—Tips of maxillary arms, with bulla.
FIG. 2041A.—Female, ventral. Lapland.
FIG. 2042.—Head, lateral. *N.O.*, nuchal organ; *Ant. 1*, antennule; *Mx.*, maxillule.

two pairs of appendages and a frontal filament. In about 20 minutes the nauplius moulted to a copepodid



Figs. 2043–2047.—*Tracheliastes polycolpus.*

Fig. 2043.—Mouth-tube.
Fig. 2044.—Antenna.
Fig. 2045.—Maxillipedes and base of arms, showing opening of maxillary gland, *Mg.*
Fig. 2046.—Posterior end of body, after Vejdovsky.
Fig. 2047.—Copepodid, stage I, after Vejdovsky.

similar to that of *Achtheres.* Vejdovsky, on the other hand, found that the larva hatched as a Copepodid, with two pairs of legs, and furcal rami with 5 setæ.

Variation.

Vejdovsky noted certain small differences in structure of antenna, maxillipede and larva from the description of Nordmann, and felt it necessary to regard his form as a var. *phoxini*.

Monod and Vladykov (1931) have discussed these differences and consider they are of small value. The maxillipedes they find to change with age, having traces of segmentation in young specimens.

Odenwall's *T. fecundus* seems to be founded only upon the precarious distinction of having more eggs in the egg-sac.

Distribution.

Germany (Nordmann).

Finland (Gadd).

Lapland: Muonio River. On fins of *Leuciscus idus* in British Museum (R. G.).

Czechoslovakia (Vejdovsky, Monod and Vladykov), on *Abramis brama*, *Barbus meridionalis* and *Barbus barbus*.

Russia (Kessler).

Lake Baical (Messjatzeff).

Britain: From fins of Golden Orfe (*Leuciscus idus*) from Edinburgh Zoological Park, January, 1930. These fish had been imported a few weeks before from Holland, so that the parasite cannot be claimed as an indigenous species.

Parasitic on the fins of the following fishes (Spandl, 1926): *Idus melanotus*, *Chondrostoma nasus*, *Barbus fluviatilis*, *Leuciscus rutilus*, *Phoxinus lævis*, *Abramis brama*.

Vejdovsky noted a remarkable restriction of habitat. He found *Phoxinus lævis* common in the Iser and its tributaries, but entirely free from the parasites except in one stream which flowed into the Iser below Turnan. In this stream a great number of the fishes bore *Tracheliastes*.

APPENDIX.

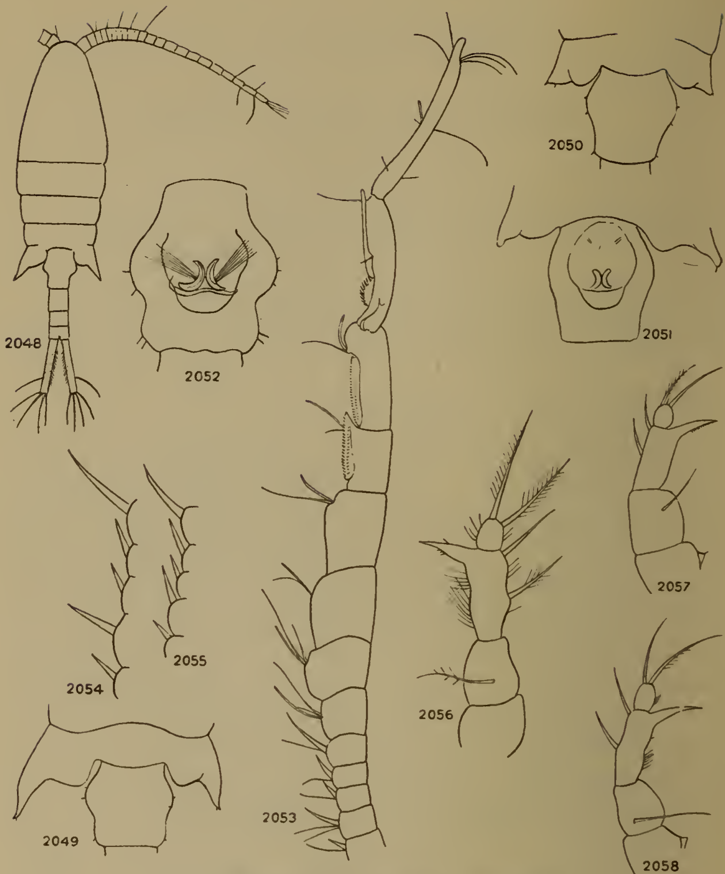
Eurytemora americana, Williams.

(Figs. 2048–2061.)

1906. *E. americana*, Williams, Amer. Nat. XL, p. 645, figs.
1923. *E. thompsoni*, Willey, Cont. Canad. Biol. N.S. I, p. 314, figs.
1930. *E. transversalis*, Campbell, Trans. Roy. Soc. Can. (3), XXIV, p. 179, figs.
1931. *E. kieferi*, Smirnov, Zool. Anz. XCIV, p. 196, figs.
1931. *E. thompsoni*, Lowndes, Ann. Mag. Nat. Hist. (10), VIII, p. 501, figs.
1932. *E. americana*, Lowndes, Ann. Mag. Nat. Hist. (10), X, p. 541, figs.
1932. ,, Wilson, Bull. 158, U.S. Nat. Mus. p. 109, figs.

Female.—Length: Lancing, 1·11–1·23; Sandown, 1·82; Plymouth, 1·33 mm.

Cephalothorax generally without dorsal hump; thorax rather slender, more or less parallel-sided; th. som. 5 distinctly separated dorsally, with rather large wings of variable form. In all cases these wings have a large inner rounded lobe, but the pointed outer part may be larger in some populations than in others. The left side is always larger than the right in British specimens. Genital somite variable, generally a little dilated anteriorly and narrowed behind, but sometimes widening again behind, to show a median constriction. Genital operculum very prominent, with rounded margin. Abd. som. 5 elongated, with dorsal surface covered with spinules. Furcal rami about 7 times as long as wide, with inner margin hairy, and dorsal surface covered with spinules. Apical setæ sometimes longer than rami. Antennule reaching to end of th. som. 4 or to end of genital somite. Leg 5, basis a little longer than wide; exopod 1 about $2\frac{1}{2}$ times as long as wide, with two long outer setæ, and inner spinous process. This segment may have an indented margin and may bear numerous marginal hairs. Seg. 2 small, oval, with two long apical setæ, which may be nearly of equal length; both margins may bear hairs. Egg-sacs generally large, with numerous eggs.

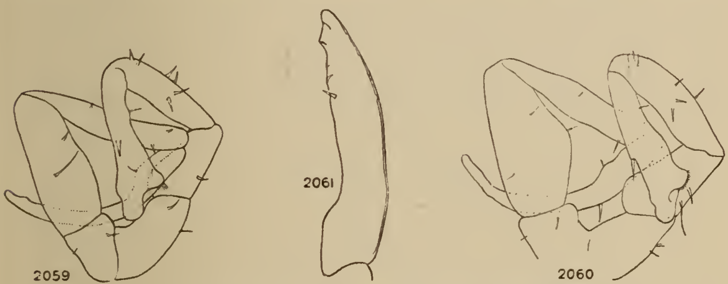


Figs. 2048–2058.—*Eurytemora americana.*

Fig. 2048.—Female, dorsal. Sandown.
Fig. 2049.—Th. som. 5, female. Sandown.
Fig. 2050.—Th. som. 5, female. Lancing.
Fig. 2051.—Th. som. 5, female, ventral. Plymouth.
Fig. 2052.—Genital somite, ventral. Sandown.
Fig. 2053.—Antennule, male. Sandown.
Fig. 2054.—Antennule, male, segs. 8–12. Sandown.
Fig. 2055.—Antennule, male. Lancing.
Fig. 2056.—Leg 5, female. Sandown.
Fig. 2057.—Leg 5, female. Lancing.
Fig. 2058.—Leg 5, female. Plymouth.

Male.—Length 1·04–1·53 mm.

Cephalothorax with small dorsal hump; th. som. 5 simply rounded. Rami and abd. som. 5 smooth dorsally. Rami 7–9 times as long as wide; apical setæ much longer than ramus. Antennule seg. 12 with very long spine; spines on segs. 8, 10, 11 shorter than spine of seg. 9; seg. 18 with prominent group of curved spines at base; terminal segment very long and slender, with finger-like distal process. Leg 5, right, basis expanded on inner side and about twice as long as wide; exopod 1 very long and slender, nearly 7 times as long as wide;



Figs. 2059–2061.—*Eurytemora americana.*

Fig. 2059.—Leg 5, male. Sandown. Inner expansion of R. leg basis hidden in this view.
Fig. 2060.—Leg 5, male. Lancing.
Fig. 2061.—R. leg, exopod 2, seen from its flattened side. Sandown.

exopod 2 long and curved, undivided, and scarcely dilated at base. Left leg, basis produced at base into small rounded lobe; exopod 1 slender, about 4 times as long as wide, but shorter than exopod 2; exopod 2 dilated at end, with stout spine on outer margin.

Synonymy.

Mr. Lowndes has recently described as independent species *E. thompsoni* from Lancing and *E. americana* from Sandown, his identification having been confirmed by Dr. Smirnov. I have seen specimens from both these places, and also a single specimen from plankton at Plymouth, and am convinced that it is impracticable

to distinguish two species. I include also *E. kieferi*, Smirnov, and the description given above is intended to cover all three. It is necessary to justify this treatment.

The description of *E. transversalis*, Campbell, is inadequate, but his three figures agree precisely with those of *E. kieferi*, and the identity cannot be doubted. *E. americana* also agrees exactly with *E. kieferi*, with the exception that, in the male, exopod 2 of left leg 5 is shown with apex segmented and reflexed. Lowndes also figures a segmented tip to this segment; but I have examined about 20 males from Sandown, and find none with a segmented apex. This segment, seen from the side (Fig. 2061), is thin and flattened, and absolutely without trace of segmentation. One specimen was seen with the end reflexed, but, in rolling it over for a better view, the segment straightened out, and was seen to be unsegmented. This character can, therefore, be ruled out, and with it any distinction from *E. kieferi*. Willey's description of *E. thompsoni* is very brief, and with one figure only, from which it is only possible to see that leg 5 female has 2 long apical setæ; but Mr. Lowndes's specimens have been seen by Willey and accepted as representing his species, so that Lowndes's description may be taken as establishing the characters of *E. thompsoni*. Now Lowndes gives as the characters separating it from *E. americana* the jointing of exopod 2 in male right leg, and differences in lengths of the spines on segs. 8–12 of the prehensile antennule. The first difference, as stated above, does not hold good; the second is so small that it cannot hold good if there is the smallest individual variation, and I do not find my own observation to agree with that of Lowndes. I find the spines absolutely identical in the two forms (Figs. 2054, 2055). There does appear to be a difference in leg 5, female, since there are no hairs on the exopod in *E. thompsoni*. But a specimen taken in Plymouth Sound, which Mr. Lowndes, after seeing my drawings, agrees to belong to *E. thompsoni*, has hairs on both

segments of the exopod. In these circumstances I see no possibility of separating the species, and no advantage in doing so. Having regard to the great variation known to occur in *E. affinis*, and to the great differences in habitat in which these forms have been found, it is much more surprising that they should agree so closely than that it should be possible to find differences between them.

Distribution in Britain.

1. Lancing, Sussex (A. G. L.): In large shallow pools not connected with sea, but with brackish water of salinity 2·49% sodium chloride, and pH 8·9. With brackish-water fauna, including *Tisbe furcata*, *Palæmonetes varians*, etc.

2. Sandown, Isle of Wight (D. J. S.): In the "Canoe Lake" in water of specific gravity 1·018–1·020. Associated with *Acartia bifilosa*.

3. Plymouth Sound, off Drake's Island, June, 1932 (R. G.). A single egg-bearing female, in ordinary marine plankton.

Distribution Abroad.

North America: Narragansett Bay (Williams); Woods Hole (Wilson); Nova Scotia (Willey); Vancouver Island (Campbell).

Asia: Sea of Okhotsk; Kamchatka (Smirnov).

The only parallel, among Copepods, to this remarkable distribution is that of *Acartia tonsa*, Dana. This has much the same distribution on the American coasts, though it extends also to the Indo-Pacific region, and has been found in brackish water in a canal at Caen in Normandy (Remy, 1927). Klie (1932) has also recorded it from Ringkjöbing Fjord on the west coast of Jutland, and from Bremerhaven at the mouth of the Weser. It appears to be a recent introduction into Europe. Compare also the spreading of recent years of the sea anemone, *Sagartia luciæ*.

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